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Proposal of a global Total Cost of Ownership Model for FMC Technologies' suppliers

By

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Preamble

This master thesis was provided and sponsored by FMC Technologies. The thesis was conducted at FMC Kongsberg Subsea throughout the spring semester of 2009. It is the final project which leads to Master of Science in Industrial and Information Management at the faculty of engineering and science. The basis for this task was the FMC Technologies' wish of investigating the true cost of having a supplier, not merely the price paid per item. The subject of this thesis is closely related to the disciplines Supply Chain Management and Strategically Economics Management.

Supervisor of this master thesis has been Dr.Ing Bo Terje Kalsaas from the faculty of engineering and science at the University in Agder. We would like to thank Bo Terje for his assist and involvement during this thesis and always coming back with an answer to our questions. The contact person at FMC has been the Global Supplier Development Engineer Michael Campbell. We really appreciate his great engagement, helpful supervising, goodwill and all the excellent conversations and talks we've had throughout the period of this project. Thanks to the Global Subsea Sourcing Director Milton Young for sponsoring this thesis, as well as given us constructive feedback and ideas to the ongoing work.

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Summary

FMC Technologies spends a huge amount of their turnover upstream to their suppliers. With indirect costs, including those that occur when suppliers have a delivery delay or deliver products of low quality, it is expected to be much higher. To be able to estimate these costs, to know the true cost of their suppliers, FMC Technologies would like to have a tool that could help them quantify and calculate these indirect costs.

To investigate and create such a tool, questionnaires were sent out, discussions with FMC personnel and in-depth investigation of their ERP (SAP) system were performed to create a foundation of the Total Cost of Ownership (TCO) model. Further, a pilot study on one of FMC's suppliers was supposed to take place in order to perform an in-depth investigation on how to estimate the TCO. Unfortunately, this task was cancelled due to lack of readily available supplier specific data in the SAP system. Therefore, no TCO analysis case study was performed.

Due to this, the thesis changed direction and it started investigating to see, if a TCO model was appropriate to evaluate FMC's suppliers. In addition to this, a conceptual model was created.

When performing this thesis, a framework used in similar approaches was inspirational, as well as the case study approach. Using the case study approach, an empirical inquiry that investigates a contemporary phenomenon within its real-life context was performed, and it is a preferred strategic choice when "how" or "why" questions are posed.

To get answers with high reliability, a triangulation of the results was desired. We achieved confirmation of our findings, often with triangulation, when concurrent results were found when either 1) interviewing FMC personnel, 2) investigating SAP, 3) reviewing answers of the questionnaires, or 4) assessing the theory or other performed case studies.

All in all, using TCO to rate suppliers could be appropriate in some cases, but when depending on responsive and innovative suppliers, the TCO approach may deliver a too narrow view, as it focuses mainly on financial measurements, and could therefore deliver a short term assessment of suppliers.

With the time consuming hard-to-quantify data, more use of subjective rating methods which also focus on the future could be satisfying alternatives, but to recommend this requires more investigation.

As there is no use of an activity-based costing system in FMC (which has a critical linkage to TCO), and no plans of implementing it, perhaps a more simple supplier rating system would be the solution. This counts especially for an innovative ETO firm, which produces low volume and customized products.

If FMC decides to use a TCO model (or any supplier rating system which focuses on historical data) they need to have a system that gathers the data regarding suppliers, preferably using the already existing SAP system. To have ambition of creating a global TCO model, without global routines seems extremely challenging.

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1 Introduction

The world of business is characterized by an intense global competition (Degraeve, 1999). "Purchased materials, components and subassemblies frequently represent in excess of 70% of manufacturing expenses" (Carr & Ittner, 1992, p 1). This is also the case for FMC Technologies, which spends 65-70% of their turnover on suppliers. This states the importance of having a tool that help firms control and estimate their expenses, in addition to an already established Supplier Performance Rating System (SPRS), or as an alternative to the latter.

The purpose of a Total Cost of Ownership (TCO) model for suppliers is to ensure that the focus is not entirely on the purchase price but also on the additional costs that occur when interacting with suppliers. These costs consist of both direct and indirect costs. Horngren, Datar & Foster (2003, p 31) describe direct costs as "… costs that are traced directly to the cost objective". Related to suppliers, direct cost could be defined as the price that is stated at the bottom of the invoice. The same source (Horngren, Datar & Foster 2003, p 31) describes indirect costs as costs: "… that are allocated to the cost object". This could be the implementation of Electronic Data Interchange (EDI), activities of purchase personnel or cost of inspecting a delivery.

It is indirect costs that occur when a supplier does not deliver on time, or delivers products of low quality. The intention of considering TCO is to quantify and display these costs. Texas Instruments discovered that when they calculated the costs of holding (cost of storage, insurance, obsolescence and money) and purchasing, the price of one single component rose from US $2.5 to US $2.95 (Carr & Ittner, 1992), an increase of

18%. The same study states that, if the component was of poor quality, the TCO rose to US $4.76, an increase of more than 60%.

Carr & Ittner (1992) further refer to another study, where costs rose from US $0.55 (purchase price) to US $100, if a defective part was not identified until the product reached the field. An increase of more than 180 times the original purchase price.

Even though textbooks as early as in the year 1928 (Ellram, 1993) state that it is important to consider the costs beyond price when choosing a supplier, most companies, including FMC, have not properly implemented or adopted methods for capturing these hidden costs. As a result of tougher competition and demanding macro financial times, the focus has now turned to considering a TCO approach when evaluating suppliers.

1.1 Research questions

This thesis has one main research question it intends to answer, and four additional questions which aim to further help answering the main one.

1. *Is a Global Total Cost of Ownership Model appropriate for evaluating FMC Technologies' Suppliers?*

- *Are there existing TCO models in any of the FMC locations?*
- *Which factors are considered in general TCO models described in the literature?*
- *How do the FMC locations gather the necessary data that is used in TCO models (if any model exists)?*
- *How can cost of Non-Quality and Delivery delays be considered*?

2 Theory from literature

2.1 Understanding Total Cost of Ownership (TCO)

To be able to investigate if a TCO model for evaluating suppliers is the best solution for FMC, an understanding of the theoretical underpinnings for TCO is essential. The reason for this part of this master thesis is to provide a foundation for an analysis if the TCO concept is appropriate for FMC as well as pointing out alternatives to the TCO concept that are more or less used as supplier evaluation tools in the industry today. The theoretical contributions will later be discussed and weighted against each other when the development of the possible model commences in chapter 3.

The theory of this master thesis is divided into four steps. The first step is to provide a general overview of Total Cost of Ownership by defining the concept.

The purpose of the second step is to present theoretical basis of the TCO concept. This consists of:

- A method for determining which products/suppliers a TCO model will be used for. As a basis for determining which suppliers to evaluate, the Kraljic matrix is considered in this thesis. Kraljic's matrix identifies the suppliers which have the highest impact on the result of a business. These are the most important suppliers where the cost/benefit of TCO analysis is likely to be greatest.

- Methods for identification of the relevant costs. Transaction costs and Activity Based Costing (ABC) are fundamental theories for the TCO concept. The purpose of explaining transaction costs is to understand the theoretical background of the cost drivers, and ABC is included to get an understanding of the importance of cost allocation. ABC is an important tool in TCO analysis when data of the selected cost elements are collected, and also when determining if TCO should be implemented.

The third step is to propose how to use TCO analysis in purchasing processes. Burdens and benefits of TCO are considered. Different approaches and types of models for TCO analyses are also looked at.

The forth step discusses alternatives to the TCO concept.

2.1.1 Definition of the TCO concept

In literature the TCO concept is defined fairly similar by various authors. Ellram & Siferd (1993) have presented a definition that summarizes the explanation that different authors have provided of the concept. They define TCO as: *"The TCO implies that all costs associated with the acquisition, use and maintenance of an item to be considered in evaluating that item and not just the purchase price"* (Ellram & Siferd, 1993, p 2). Another definition by one of the authors, claims that TCO: *"... is aimed at understanding the true costs of buying a particular good or service from a particular supplier"* (Ellram, 1995, p 1)

TCO is not only considered just as a tool, but also regarded as a philosophy, because the adoption of TCO may require a cultural change where the focus is towards total cost understanding, not merely on price (Ellram 1995). "Lack of understanding TCO can be very costly to the firm. Poor decisions will likely result in hurting the firm's overall competitiveness, profitability, pricing decisions and product mix strategies" (Ellram 1995, p.6).

However, there is no standard TCO model stated in the literature. A case study conducted by Ferrin & Plank (2002, p 11) supports this statement by concluding the following: "*This research suggest that a standard TCO model will not exist, but some cost drivers are more universal than others and will appear in many TCO valuation models*". In this master thesis the latter is acknowledged. However, there are presented methods and examples in the literature that can provide layouts for new models.

For this master thesis, TCO is defined as; *"All **relevant** costs associated with the acquisition and use of an item that can be related to a **specific supplier**"*. Relevant costs meaning costs that will fit the Pareto-principle that will be presented in the following chapter. Relevant data can also consist of easily obtainable data that with little effort can be implemented in a TCO model.

2.1.2 Creating a TCO model

Vision and strategy

When a business decides to develop a TCO model, or any Supplier Performance Rating System (SPRS), it should start with considering its vision and strategy (Malina & Selto, 2004). A business can have a vision/strategy both for the general business, and also a separate one for the purchasing part. The vision/strategy that focuses on purchasing, should origin from the main vision/strategy, and the TCO/SPRS should have underpinnings in the purchase strategy.

"A vision statement outlines what the organization wants to be. It concentrates on the future. It is a source of inspiration. It provides clear decision-making criteria." (Wikipedia)

Further, the vision should consist of the following (Beach, 2005)

Goal
Goals are the most important part, the well defined subject of the vision. A vision can consist of several goals, which the business can strive towards.

Priorities
Priorities refers to the goals, some are more important than others. It gives weight to the different goals.

Requirements
This describes what is needed to reach the goals. Obstacles of reaching these goals can be knowledge, skills, leadership and money.

Implications
Define the pitfalls, and minimize these. If this is performed properly, the chance of reaching the vision increases.

"A strategy is a plan of action designed to achieve a particular goal."
(Wikipedia)

It is important for a business that the vision and strategy are widely spread among the employees, and also upstream the supply chain. An efficient way of distributing the vision/strategy is to integrate a TCO model or SPRS with suppliers. This will maintain the right focus at the key suppliers, and they will indirectly transfer this strategy upstream to their suppliers again.

2.2 Theoretical basis for the TCO concept

The influence a supplier has on a customer is often determined by the impact it has on the customer's business. A major supplier that delivers large quantities of goods is likely to have a significant impact on the customer's profit. As the hypothesis for this thesis and the Pareto principle utter, 20 % of the suppliers account for 80 % of the costs. Therefore it is in most cases most valuable to apply a TCO analysis to suppliers that fit this category.

Ellram & Siferd (1993, 1995) state that transaction costs and activity-based costing provide the theoretical basis for the TCO concept and it can be considered as the foundation for TCO analyses. These two methods combined will constitute the majority of the additional costs that occur during transactions between suppliers and customers. However, the necessity of including all costs in addition to the purchase price will limit

it-self by the complexity of the TCO model. If the model becomes too complex, the work related to gathering relevant data from the processes related to acquisition and use of an item are likely to require more costs than the benefit the model will provide.

2.2.1 Pareto principle and hypothesis

"For many events, roughly 80% of the effects come from 20% of the causes" (Wikipedia). The Pareto principle claims that when transacting with suppliers, 80% of the costs are caused by 20% of the cost elements. This is called the 80-20 rule. The aim of this thesis should be to locate those 20% cost drivers that cause 80% of the costs After reasoning with the FMC supervisor, assessing the research questions and evaluating some of the literature (Carr & Ittner, 1992), the use of the Pareto principle became evident. Quality of products from suppliers and delays of deliveries look like the two biggest cost drivers that occur, which also creates the hypothesis for this research: "*cost of quality and delays are the two biggest cost drivers, and could make up about 80% of the indirect costs that occur."*

2.2.2 Categorization of suppliers

In an article, Kraljic (1983) argues that different suppliers are of different strategic importance for a customer. He developed a framework (Figure 2-1) that is based on two dimensions, business impact and market complexity, for classifying suppliers into four categories of strategic importance. Different purchasing approaches are required for each category and the framework is commonly used by procurement staff to determine what type of relationship each supplier requires and which supplier fits under the Pareto principle.

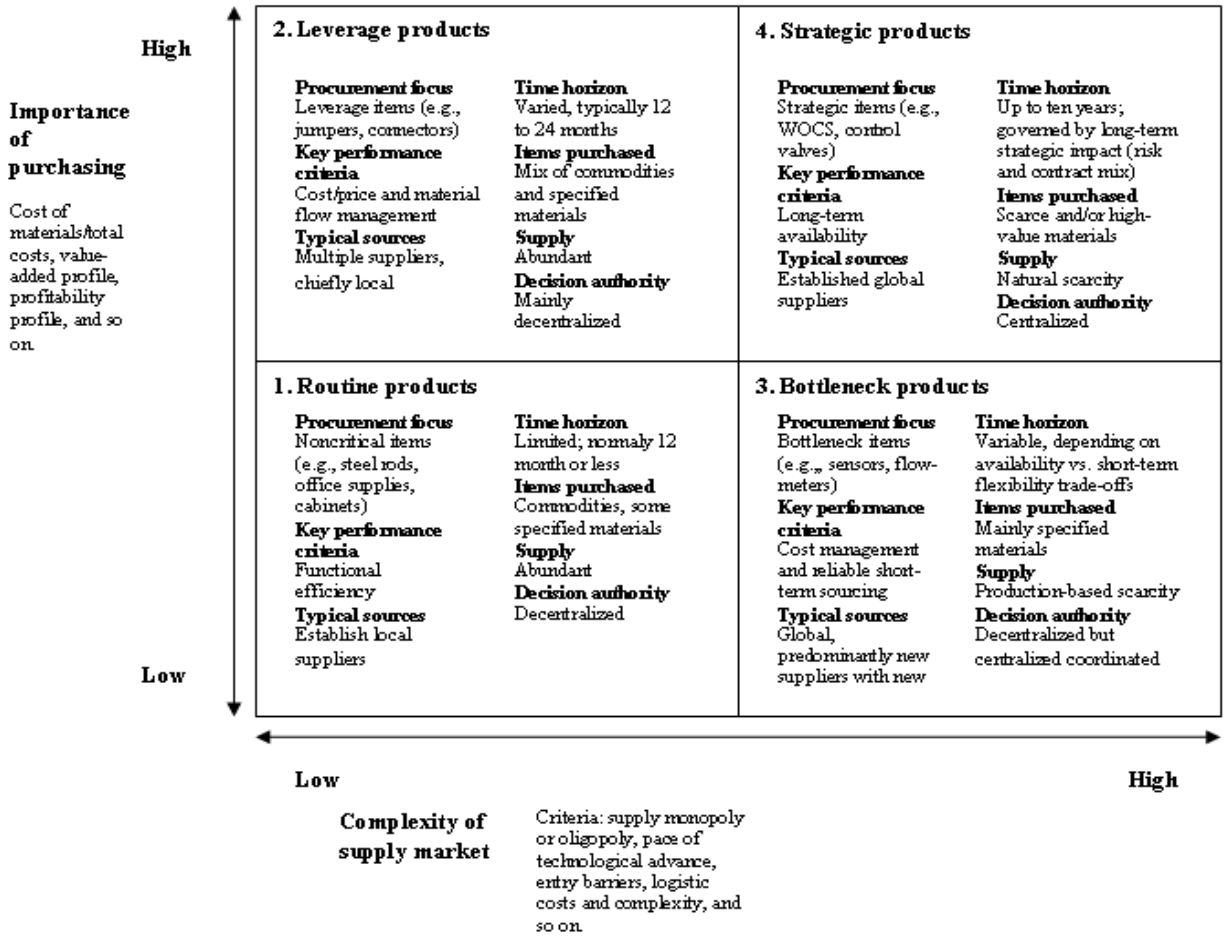


Figure 2-1 Classification of suppliers using Kraljic's matrix

As Figure 2-1 shows, there are four categories that exist for routine products, leverage products, bottleneck products and strategic products.

Routine products are non-critical items with low financial impact and low supply risk. It is recommended that these items are sourced using as few man-hours as possible, and the focus should be on standardization and increase of the efficiency of the purchasing process.

Leverage products are products of high financial impact and low supply risk. These products are often sourced by competitive bidding among several suppliers.

Bottleneck products are products that are limited to relatively few suppliers, and have a low financial impact on the customer. The strategic focus should be to secure the supply and be on the lookout for potential new suppliers.

Strategic products are products that have a high financial impact and high supply risk because of the complexity of the product or shortage in the market. It is recommended that the customer and the supplier work in close cooperation, where the goal is to achieve better profit and knowledge over time.

2.2.2.1 Supplier categorization in TCO

How is Kraljic's categorization matrix related to TCO analysis? Ellram states in an article (Ellram, 1993, p 4) that; "TCO is time consuming and should be used only where it is likely that the cost saving potential exceeds the cost of modelling". With regards to this statement Kraljic's matrix can be used as a decision tool for which suppliers have the greatest impact on the profit and where a TCO analysis should first be implemented. However, it is not always that strategic and bottleneck suppliers that supply products of high value are suitable for being evaluated by TCO. As a supplier becomes more important, as the strategic and bottleneck suppliers tend to be, the evaluation of these would in many cases be better off with a more including assessment and aim of forming the relationship for future collaboration.

As shown in the section above an enterprise can categorize its suppliers by applying Kraljic's matrix. Using this information the enterprise can determine the suppliers of interest. In the next section two theories for cost identification and allocation are looked at.

2.2.3 Activity-based costing

The purpose of activity-based costing (ABC) is to determine the indirect costs that occur when producing a specific product. (Horngren, Datar & Foster, 2003). ABC identifies each activity related to the product that is acquired and can be a practical starting point when developing a TCO model. Activities that are likely to being included in a TCO model are the costs of ordering an item, freight costs, cost related to receiving the item and costs associated to the use of the item. The main challenge is to correctly distribute these costs among the activities, as it can be time consuming and a work that requires close follow-up on specific performance.

"The need to measure more accurately how different products and services use resources has led companies such as American Express, Boeing, General Motors and ExxonMobile to refine their costing system"(Horngren, Datar & Foster 2003, p 136)

A typical result from ABC is that low volume generates higher costs, and high volume generates lower costs per article. This due to the number of products the indirect costs are divided on, as the indirect costs remain constant.

"The term cost smoothing, or peanut-butter costing, describes a particular costing approach that uses broad averages for assigning (or spreading, as in spreading peanut butter) the cost of resources uniformly to cost objects when the individual products or services, in fact, use those resources in a non-uniform way" (Horngren, Datar & Foster 2003, p 136)

If the "peanut-butter costing" (full cost costing or gross margin calculation) is used, product under-costing and product over-costing will constantly occur. This implicates that some products might be sold with loss, and others may perhaps be sold with a very high margin. The result can be very unfortunate for the business, as one product actually subsidizes the other.

Further, when evaluating suppliers with the ABC method it is (as mentioned earlier in this thesis) of high importance to consider more than just the price. There are short term measurements, such as: price, delivery (time & terms) and quality. Long term measurements could be: capacity to innovate, will to integrate, and collaboration.

As an example, when calculating the cost of quality one should consider 4 categories: (Horngren, Datar & Foster 2003, p 661)

> *Preventive actions*, such as selecting suppliers and teach the supplier the expected standards
> *Inspection costs*, costs that occur when inspecting deliveries.
> *Internal costs* occur when a product with low quality is detected. A consequence could be a delay in production.
> The last category is *external quality costs*, which are costs connected to low quality products that are delivered to customers. Those costs could be measured in bad reputation and disloyal customers (even though it is hard to quantify these costs).

Activity based management

Adoption of ABC for evaluating suppliers, could be a useful tool to help determining which suppliers provide highest value for the business. This helps firms determine which activity needs the most attention, in effort to increase earnings and decrease expenditures. Thus increase the profitability. This is called activity-based management (ABM), and it should be the foundation of decision making when it comes to pricing, improvement of processes and reduction of costs. The goal of ABM is to eliminate the non-essential, *non-value adding costs.* Examples of this can be unnecessary transportation, delays of delivery, poor quality, extra coordination and inaccurate work. All in all, ABM is used to improve the business result in the most efficient way, and the Pareto principle could also here be used as a guideline.

- A study (Kennedy and Affleck-Graves, 2001) performed on British firms claims that they increased their profitability in general with more than 20% after implementing ABC compared to similar businesses.

- In Norway a study (Kjøde, L.A 2003) states that about 30% of larger industrial businesses had implemented ABC.

2.2.4 Transaction costs

Transaction costs analyses have been viewed by economist primarily from a make-or-buy perspective (Ellram 1995). When regarded from a TCO perspective it is also applied *after* a firm has decided to buy externally rather than using an internal supplier.

The transaction cost analysis explains the reason *why* the indirect costs appear, not how to calculate or estimate the costs. To get a thorough evaluation of how a company is performing on the cost related side of the business, a transaction cost analysis must be combined with other methods such as the activity-based costing.

Transaction cost consists of the expenses linked to business between two parts, often called the principal and the agent (Askildsen & Kalsaas 2009), were the principal is a company that hires the agent to get something done (Wikipedia). As well as calculating the direct costs, one must also consider the indirect costs. These costs are in many cases hidden, and more difficult to determine. Never the less, these are important to include in the process when estimating the Total Cost of Ownership (TCO).

Kalsaas (2009) claims that when a business is in the process of establishing a relationship, it will perform a thoroughly investigation of the suppliers that are considered. These exploration costs will be followed by costs that are predetermined by the negotiations done by the involved parts. These are again followed by additional costs that occur during the relationship between supplier and customer. The magnitude of the transaction costs varies depending on several factors, such as:

Length of relationship

The longer the relationship lasts, the more the involved parties start to get known to each other. The start-up problems have decreased, and each transaction between them is performed with less efforts. As trust between the parties increases, an investment in an EDI (Electronic Data Interchange) system will be more likely as it is expensive, and not suited for a short term relationship. This will further help increase smoother, cost efficient transactions between the parties.

Frequency of transactions

The more often the transaction is performed, the higher the costs are. Both transportation costs and the administrative costs will rise. The decision on how frequent the transactions shall be performed must be done after a cost/benefit analysis.

Trust

If there is little trust between parties in the supply chain, the need for inspections and thorough follow-up increases. This is due to the increasing risk of deliveries of low quality or late deliveries.

Risk

The more risk one of the actors is exposed to, the less he will be willing to pay. Transactions that have a lot of risks involved require more efforts from both sides, thus bumping up the transaction costs. Risk and reward are two highly dependant factors. If the risk in an investment rises, the reward must rise as well, in order for the investment to be valuable. A consequence of higher risk is either a lower buying price or a higher reward of the invested money.

Power

In relationships where one of the participants holds more power than the other, he can use his advantage and therefore increase the price of the supplying items or request lower prices on buying goods. The impact power has on supplier-customer relationships will not be investigated in-depth in this thesis, as it is challenging to quantify it.

Uncertainty

The more uncertain the customer is of his order, the more precautions he will take. This means that he would order a larger amount or widen the time margin if he expects the supplier to deliver poor quality or being delayed. Another alternative would be to closely follow up the transaction.

Rational behaviour

If the level of power between the principal and the agent is equal, one can expect rational behaviour. If one of the participants feels that he has the upper advantage, in one way or another, he can use this in his advantage and create a mark-up or otherwise exploit it. If the supplier is innovative and has a superior product, he can intentionally choose not to collaborate with the customer when it comes to developing products. The flow of information can therefore be almost just one-way, and a disadvantage is created for the customer.

To determine how to lower the overall costs in a business, one should use a cost/benefit analyses to determine the amount of efforts used in collaboration with suppliers. The more efforts, the higher the transaction costs will be. On the other side, more time spent on suppliers will have effect on other parts of the process, such as quality of product or trust between the involved parts.

2.2.4.1 Transaction costs in TCO

Transactions costs can be important factors in TCO analyses due to the significant variation of these costs among suppliers. Transaction costs may involve factors that are hard and costly to replace and therefore should this be accounted for in some way. Due to this, the transaction cost analysis is in purchasing and logistic literature regarded as a theoretical basis for TCO (Ellram, 1995). When developing a TCO model the following supplier-customer matters should be regarded:

Are there particular investment costs between the supplier and the customer, such as EDI systems?

Are there uncertainties that will contribute to an increase in transaction costs? This increase in transaction costs comes from compensatory actions that are likely to be expected. These actions could consist of more man-hours spent on following up the supplier or more thorough and costly inspections.

Frequency is divided into single, periodical and continuous deliveries. Higher frequency is likely to result in an increase of transaction costs. This increase can come as a result of necessary investments made to maintain the relationship. Higher frequencies will in many cases also increase the learning effect and develop a closer relationship between the two parts. The latter will contribute to a decrease in the transaction costs.

Are there any signs that show that limited rationality and opportunistic behaviour is of such serious degree that it will contribute to higher transaction costs? These costs are hard to quantify into monetary terms. Humans have limited capacity to manage information without error and to communicate in a clear and precise way. This is regarded as limited rationality. Opportunistic behaviour is when one of the trading parties seeks self-interest in a false way. An example would be if someone benefits from exploiting vagueness in a contract. Counteracting these factors by introducing preventive actions will probably increase the transaction costs.

This section has focused on cost identification and allocation. In the next section the focus is on which of these costs to include in a TCO model, from a cost/benefit perspective.

2.2.5 Cost/Benefit analysis (CBA)

To determine how to reduce the overall costs in a business, one should use a cost/benefit analysis to determine the amount of effort used in collaboration with suppliers. The more

efforts, the higher the transaction costs will be. But as mentioned earlier, more time used on suppliers will have effect on other parts of the process, such as quality of product or trust between the involved parts. To help deciding the most cost efficient level, a method called cost/benefit analysis may be used.

2.2.5.1 ALARP – As low as reasonable possible

ALARP points out the preferred level of effort one should use in the relationship with a supplier. Invest time and money until you reach that point where it is no longer *cost efficient*. This could typically be when ordered products reach a certain percentage of On Time Delivery (OTD) or a point, where the quality of a product is within a certain limit. As an example 98% OTD and 3% products of low quality may be acceptable from suppliers. To reach 2% of products of low quality would be more expensive than the cost of holding extra inventory.

One of the main challenges when performing a CBA analysis is to determine when enough effort has been invested.

(NORSOK STANDARD, 2001)

2.2.6 Total cost of ownership in purchasing

It is mentioned in literature that there are several important dimensions to consider for vendor selection. The problem is how to select suppliers that perform optimally on the desired dimensions. Traditional cost systems have the disadvantage of only tracking the purchase price associated with a supplier or a particular part (Degraeve & Roodhooft 1999) (Ellram, 1995) (Carr & Ittner, 1992). The total cost of ownership concept acknowledges that there are more costs to take into account than only the actual item price. In addition to the obvious costs related to the item price, there are several other relevant costs throughout the entire value chain that make up the total acquisition price

per item. Carr & Ittner have presented a general list of costs to consider in the article "Measuring the Cost of Ownership" when applying a TCO analysis (Carr & Ittner 1992):

- The cost of purchasing, such as ordering, freight, and incoming quality inspections.
- The cost of holding, related to storage, insurance, obsolescence and compulsory savings
- The cost of poor quality includes the costs of rejection, re-receiving, scrap, rework, repackaging, downtime and warranties.
- The costs of delivery failures are costs related to expediting, premium transportation, downtime, loss of sales.

Ellram has also presented a set of factors to consider in the development of a TCO analysis. These factors are presented in Figure 2-2, and are divided into six groups:

- Management, Delivery, Service, Communication, Price and Quality.

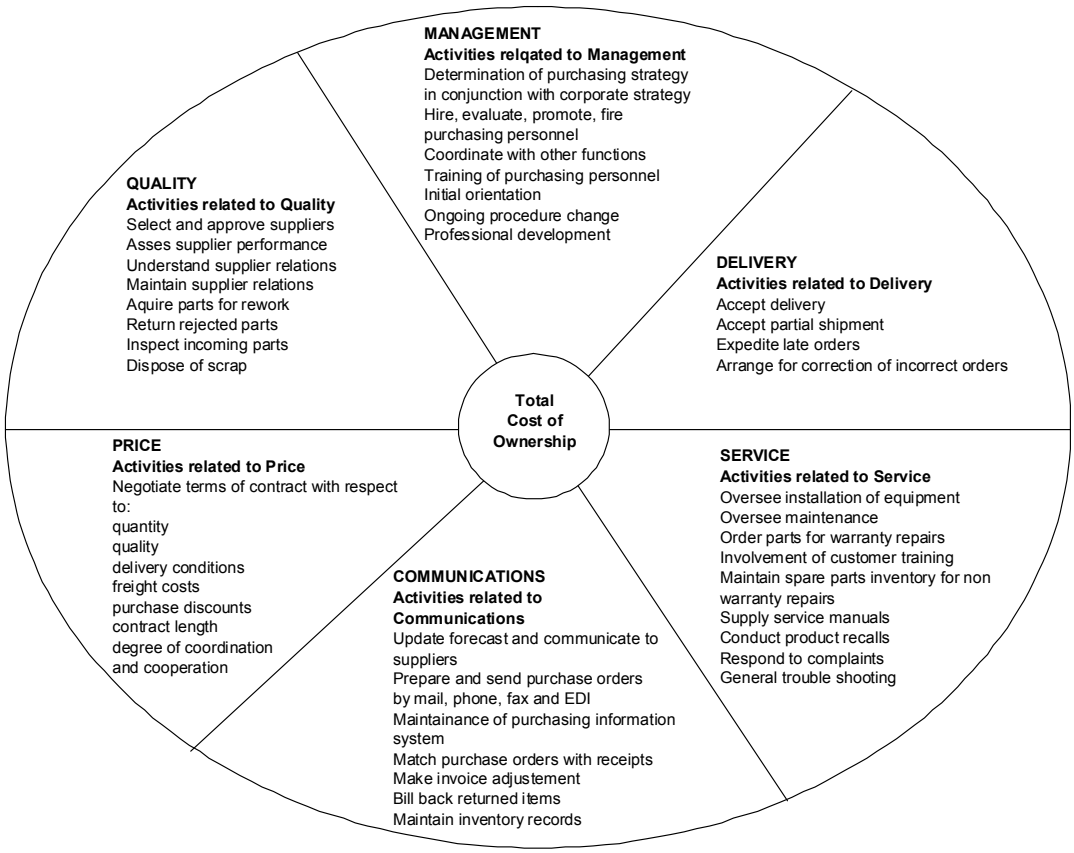


Figure 2-2 Purchasing activities contributing to total cost of ownership (Ellram & Siferd, 1993)

The presented cost elements by Carr & Ittner (1992) and Ellram & Siferd (1993) must be considered very generally. In addition, it must be considered that some of the cost elements from the beginning of the 1990s could have changed. Especially in the category "communication", where the use of ERP and Internet have been introduced.

Many firms tend to "hide" these costs by placing them in overhead costs or general expenses. TCO attempts to identify the true costs of activities related to procurement to support firms making decisions regarding for example evaluation of suppliers or selection of potential suppliers (Ellram 1995, LaLonde & Pohlen 1996).

In a case study of eleven firms conducted by Ellram (1995), she found that various firms practicing TCO have different primary use of the concept and the outcome of the

different models is highly unique to each firm (Ellram 1995). There are various approaches to TCO when it is implemented and adopted, as will be shown in chapter 2.2.8. TCO analyses are versatile in that way that they can and should be adapted to a firm's specific procurement strategy and needs (Ferrin & Plank 2002). One firm may need to evaluate and measure their suppliers over time as a primary objective; another firm may use it as a tool for make or buy decisions. In general TCO analyses help determining which supplier offers the best overall value by providing more accurate information on performance in terms of costs.

2.2.7 Burdens and benefits of TCO adoption

A TCO analysis is based upon a set of factors that not always are measurable in monetary terms and the needed data for making TCO models work are not always present. It is for that reason regarded as a complex tool. When adopting TCO, a common barrier to numerous organizations is that the accessibility of accounting and costing data is not readily available (Ellram & Siferd 1993, Ellram 1995). When adopting TCO it is of great importance to get hold of the relevant data to perform the analysis. These data depend on the complexity of the developed model and can vary widely from company to company. Quality, technology, support and service are examples of factors that the company may need to provide as relevant data. In quality it can be relevant to include costs of defects, inspection and rework. For technology, data such as cost of having engineers at the supplier's facility may be necessary. Support and service can be evaluated as cost of delivery delays, handling and invoice distribution (Ellram 1995).

As previously mentioned, TCO does not have a standard approach for implementation and can be regarded as a complicating aspect (Ferrin & Plank 2002). Although some approaches utilize similar cost elements, the models and costing data provided are likely to be unique to different companies. Another factor that can contribute to its difficulty is

training of personnel that will adopt and use the model (Ellram 1995, 1993). Therefore, there can be a challenge of making a model that is both practical and usable, and at the same time contribute to a beneficial result. This is important to have in mind when developing a TCO model. There may be a need for a cultural change in the organization that considers implementing a TCO analysis in their procurement and sourcing procedures (Ellram 1995, 1993). Decision making when analyzing a TCO model may be implicated by various factors such as nature, magnitude and importance of the buy (Ellram 1995). These factors are situation specific and costs are likely to vary because of this. Another point worth noting when dealing with TCO is that it does not capture the upstream firms cost (LaLonde & Pohlen 1996). These costs are simply reflected as the purchasing price and will not be reviewed further by any TCO model as described in the literature.

Sub-optimizing when making decisions based on the TCO is a problem that may be encountered, because the TCO model can be very cost specific. If the persons that perform the TCO analysis just consider the costs, important factors such as relationship with the supplier and supplier responsiveness can be neglected (Kalsaas, 2009). Thus, if the TCO model is fitted to the organization and takes into account the factors that will contribute to a comprehensive picture of the supplier; TCO will contribute to choosing the right, as well as the most cost efficient supplier.

TCO analysis can be sensitive to who performs it. If the model that is used is highly dependent on qualitative consideration, which will be looked at later in this thesis, the outcome of the analysis can differ based on a person's opinion. E.g. hypothetically this may occur if two people measure the same supplier. Their experiences with the supplier's performance on on-time-delivery (OTD) may be different. One of them concludes with top score because of their good figures on OTD. The other one concludes with a mid score on OTD performance because he knows that the good figures are due to all the expediting done by him as the customer.

Another point of importance is that models based upon activity-based costing (ABC) require a wide-ranging management accounting system that provides relevant costs of the acquisition process (Degraeve, Labro & Roodhooft, 2000). SAP and Oracle are examples of such ERP systems that can provide the needed data if adopted accordingly.

However, there are arguments that using TCO will exceed the barriers when the concept is adopted properly. This is stated in literature and confirmed by case studies (Ellram 1995). The key benefits of adopting a TCO concept are summed up in the following points:

- A tool for evaluation and support in the process of selecting the best suppliers. It makes the process of comparing supplier performance over time efficient.
- Assists determining in which areas the supplier performance is good and where it can be improved. From this information it can be evaluated where it would be most beneficial to start an improvement process and cost saving activities.
- Improves employees understanding of supplier performance structure and cost structure
- A tool for negotiations. By making the activity costs visible, it can justify a higher purchase price because of lower total costs in the long run. As an example there are in many cases severe costs attended with quality issues. This can impact the total cost in a harsh manner.
- According to what is mentioned above the TCO concept provides a long-term purchasing orientation by emphasizing the TCO rather than just the piece price.
- Focus on continuous improvement of the supplier relation.

The list above sums up the general key benefits of TCO adoption, but the benefits also rely on the unique implementation in various firms. TCO is not likely to be used in all procurement situations, but rather as a support where the organization feels this analysis

can provide the greatest benefit. Typically on suppliers that fit the Pareto 20-80 rule that was explained in chapter 2.2.1.

2.2.7.1 Discussion of theory

In the case studies Ellram presents, there are some weaknesses. It is argued that the TCO model can measure what it is designed to measure. In reality, measuring subjective values in a TCO model can be challenging and increases the threshold of using such a model. The varieties of the users with different opinions are also likely change the result, especially when users will be located in different locations of the world.

Most of the case studies found on the subject are conducted in the beginning of the 1990s. It is worth to notice that the focus on how to evaluate suppliers could have changed, and that is the reason for the lack of recent case studies. Something that has changed during this period is the use of ERP systems and increased globalisation.

Most of the firms described in the theory, are described in a vague manner. They are described as an "oil firm" or "electronics manufacturer". It is not further described what their competitive advantages are, if they produce cheap products with low variance, or if they produced tailored innovative products. How the supply bases of the different firms are built up, if they consist of responsive and adaptive suppliers, or if they are cost efficient and not flexible. These are factors that are important to include when designing a SPRS, and also factors that are important when creating a supply base. To help designing a suited supply base, an overall Supply Chain strategy would be of support.

2.2.7.2 Burdens and benefits of TCO summarized in a table

Burdens	Benefits
TCO is regarded as a complex tool and requires willingness and dedication to implement	A tool for evaluation of suppliers that accounts for both direct and indirect costs
Dependent on data that not always are present in the company's systems	TCO creates an awareness of the importance of considering all costs, not just the item price
Training of personnel required	Can serve as a tool for supplier negotiation
TCO adoption can require a cultural change in the organization because of possible changes in the company's systems and methods for registering costs	TCO can create improvement of the suppliers. Costs related to improvements as well as to quality and OTD.
Use of TCO can create an incentive for sub optimizing.	Increases customer value
Subjective quantifying of data required	Provides focus on continuous improvement
Very dependent on activity-based costing	

Figure 2-3 Burdens and benefits

As mentioned in this chapter the TCO analysis can be fitted to the actual purchasing process and various factors to consider are pointed out. The next chapter will examine two different approaches for analysing TCO.

2.2.8 Approaches for determining TCO

As mentioned there are various approaches and several reasons for a firm to use TCO as a part of their procurement strategy. However, there are two major approaches that designate themselves, the dollar-based and the value-based approach. In a case study

conducted by Ellram, (Ellram, 1995) eleven companies from different industries were studied in relation to their use of the TCO concept. The study shows that the adoption of TCO and the primary use of the concept among these companies varied a lot. However, the value-based and the dollar-based models will, in many cases, fill the same role; it depends on the company which model it prefers. On the basis of the case study by Ellram, this thesis will take a closer look at the dollar-based and the value-based approach.

2.2.8.1 Dollar-based approach

This method relies on gathering data or allocating actual costs from relevant cost drivers that are quantifiable. The approach is based on activity-based costing (ABC) analyses where each cost element of importance is accumulated to provide the total cost of ownership for the actual investment or supplier. The dollar-based approach provides a straightforward result that is given in actual cash spent per item (Ellram, 1995). This makes it a tool that provides an understandable result for explaining and demonstrating to the staff and managers who do not have the hands-on experience with the TCO term. An example of this approach is showed in Figure 2-4.

Price paid, F.O.B		$12000	
Price per unit (Price paid/units shipped)		$12,62	
Delivery charge		$500	
Quality:			
Cost to return defects	$100		
Inspection (in-house)	$300		
Delay costs (downtime)	-		
Rework parts	-		
Rework finished goods	$200		
Subtotal quality costs		$600	
Technology:			
Our engineers at their facility	$1500		
Subtotal technology		$1500	
Support/service:			
Cost of delivery delays	$104		
Charge for not using EDI ($50,00/order)	$150		
Subtotal support/service		$254	
Total costs		$14854	
Units shipped			950
TCO per unit (total costs/units shipped)		$15,64	

Figure 2-4 Example dollar-based approach (Ellram 1995)

Figure 2-4 shows an example of how a dollar-based model may look like. First is the price paid, $12000, for all ordered items. This translates to $12.62 per unit. Then all additional cost elements that are considered relevant are added as they occur. How these costs are calculated will be further reviewed below. As a result of the added costs the total cost for all items have increased to $14854 or by 19.2 %. And the costs per unit have increased to $15.64.

Although the dollar-based approach presents an understandable result, the determination of elements to include and how to measure these can be complicated. There are two variations of the dollar-based method used in Ellram's (1995) case study.

One approach uses formulas to allocate costs by item purchased from the supplier. The effort or resource level required to perform a certain activity is the basis for this formula (Ellram, 1995). Take the activity "inspection" as an example. To determine the costs of an inspection one must look at the effort required to completing this activity. The formula

has to fit the activity it is measuring. This can be challenging in cases where there are several factors that contribute to the actual costs of the activity or when the contributing factors are complicated to measure in monetary terms. As for the inspection example, one complicating factor is that the consumed inspection time for different products can vary a lot.

The other method uses direct costing to calculate the activity costs (Ellram, 1995). In this method the indirect costs are omitted and only the variable costs that are directly related to the product or activity are taken into account. Therefore the direct costing model considered simpler than and not as accurate as the formula-based model. This thesis will concentrate on the formula dollar-based approach, and will not focus the direct costing method.

The advantages and disadvantages of the mentioned methods for a dollar-based approach are considered in Figure 2-7. But generally the formula-based model attempts to go a bit further by allocating more or less the exact costs of an activity. The dollar-based approach creates a methodology for using the TCO approach both for repetitive decisions and unique analyse of a supplier (Ellram, 1995).

2.2.8.2 Value-based approach

The value-based TCO model depends on both cost/monetary data and qualitative data that are attempted transformed into quantitative data, which is not always is easy. This makes it quite complex in contrast to the dollar-based approach.

There are some similarities to balanced scorecard where qualitative performance data such as innovative capabilities and responsive feedback are measured. The value-based method attempts to take this one step further and translate this into a unitary term. As shown in the example in Figure 2-5 and Figure 2-6, the value-based approach awards the supplier with a score. Then a formula translates the score into a total cost per unit. It is necessary to have strict directions on how to evaluate the scores so that the variation is

kept to a minimum if the analysis is carried out by different people. The development of a value-based approach does require a great deal of fine tuning and effort to get the right weighting of the different cost categories. For example the quality parameter can be of higher importance for one firm that relies on high-quality goods than for another firm where on-time delivery is of more importance. This flexibility is one of the reasons organizations prefer a value-based approach. That the "weighting" of the method can be changed according to the organizations priorities is regarded as an advantage of this approach. When using a value-based model the number of factors that are considered should be kept low, generally three or four. When involving more factors, it tends to become too complex. It is also very likely that the major cost drivers are represented by this number of factors (Ellram, 1995).

Total cost of item per dollar purchased = [(100 - score)/100] + 1

Category	*Maximum points*
Quality	30
Delivery	20
Technology	30
Support	20

Example: Delivery "% of line items delivered on time" (A)	Percentage of maximum points allotted (B)	Score (Max score(20) x B)
100 %	100 %	20
99 %	95 %	19
95-98%	85 %	17
90-94%	70 %	14
85-89%	45 %	9
80-84%	25 %	5
<80%	0 %	0

Note: Corrected formula for score-calculation from (AxB) to (maximum score for each category x B)

Figure 2-5 Example value-based approach (Ellram 1995)

Example: Acme's Score	Month ending 12/31/92
Category	*Points awarded*
Quality	25
Delivery	19
Technology	30
Support	18
Total score	92

Total cost per item per dollar purchase = [(100 - 92)/100] + 1 = 1,08 total cost factor

Adjusted cost per unit = Price X total cost factor = $10,00 unit X 1,08 = $10,80/unit TCO

Figure 2-6 Example value-based approach (Ellram 1995)

The two figures above are examples of how a value-based model may be used. It is important to have in mind that these are just examples, and must in every case be adapted to the organization where it is used. In this example there are four categories that are measured for a given supplier. The categories are weighted differently, but within the limit of 100 points. So the contributed possible top scores from all categories will not exceed 100 points. Take for example "deliveries" for how the score is measured. The maximum score to achieve is 20, when 100% of all deliveries are on time. If 99% of all the deliveries are on time the score will be 95% of 20 that is rounded to 19. Calculations like this will be done for all the categories and as for the example, the scores in each category sum up to a total of 92 out of a maximum of 100. The score is then converted to a unitary term by the formula and adjusted so that the outcome is a TCO per unit.

A main benefit with this TCO-concept is that it is highly versatile in how it is implemented and it should be developed to fit the strategy of the organization where it is adapted.

Model advantages	Disadvantages
Dollar-based - direct cost	
Tailor factors considered to decision	Time consuming
Very flexible	Does not make sense for repetitive decisions
Alter level of complexity to fit decision	Not cost beneficial for low dollar buys
Help identify critical issues	
Dollar-based - formula	
Easy to use once system is in place	Time consuming to establish system
Excellent for repetitive decisions where costs for key factors can be determined	Formula needs to be periodically reviewed and updated
	Inflexible to different types of decisions
	Considers a limited set of factors
Value-based model	
Can incorporate issues where costs cannot be determined	Time consuming to develop; only good for important and/or repetitive decisions
Considers the importance of factors using weighting	Much judgement in establishing weightings
Easy to use for repetitive decisions	

Figure 2-7 Advantages and disadvantages (Ellram 1995)

Type of model	Primary uses
Dollar-based - direct cost	
	Supplier selection
	Supply base reduction
	Make versus buy/outsource
	Process improvement
Dollar-based - formula	
	Supplier volume allocation
	Supply base reduction
	Ongoing supplier evaluation
	Process improvement
Value-based	
	Supplier selection
	Make versus buy/outsource
	Process improvement

Figure 2-8 Primary use (Ellram 1995)

As indicated in Figure 2-7, according to the case study there are advantages and disadvantages with the different approaches. The different companies have also various

primary uses of their implementation of TCO as shown in Figure 2-8. This study illustrates, as mentioned before, the versatility of TCO.

2.2.8.3 Unique versus standard models

The decision whether to use a standard or unique model is dependent on where the model is adopted and what it measures. The unique model is more suitable in situations where there is a desire for flexibility, and where the various buys rely on different cost factors that have different importance to the specific purchase. The unique models are adaptable and efficient tools for calculating the true cost of a supplier. On the other hand these models require a great deal of work when they continually have to be fitted to the unique buys of an organization. The standard models on the other hand are favourable because of their user-friendliness and desire to analyze repetitive purchases. This makes them a better tool for comparing suppliers because they are measured on the same terms. The maintenance of a standard model also requires less work (Ellram, 1995).

A study of organizational purchasing models, with the focus on TCO, has been conducted by Ferrin & Plank (2002). This study shows that out of 115 respondents only 4,3 % have no variation in the cost drivers when performing TCO analyses on various commodities. 40,8 % have a major or a high variation of cost drivers included in the TCO. In one question the respondents were asked to identify and describe the key cost drivers in a purchasing situation. A total of 73 respondents generated a list of 237 cost drivers. The authors indicate that an important finding of this study is the staggering number of cost drivers available and appropriate to include when implementing TCO. They also propose that a standard TCO model will not exist, but some cost drivers are more universal than others and will appear in many TCO models (Ferrin & Plank, 2002).

2.2.9 Identifying cost drivers

As mentioned earlier in this thesis, a TCO model tries to quantify the indirect costs that occur in the process of managing suppliers and the products they deliver. As the hypothesis states, there are two main cost drivers; poor quality and delivery delays.

Horngren, Datar & Foster (2003) describe the Costs Of Quality (COQ), and categorize this in four categories.

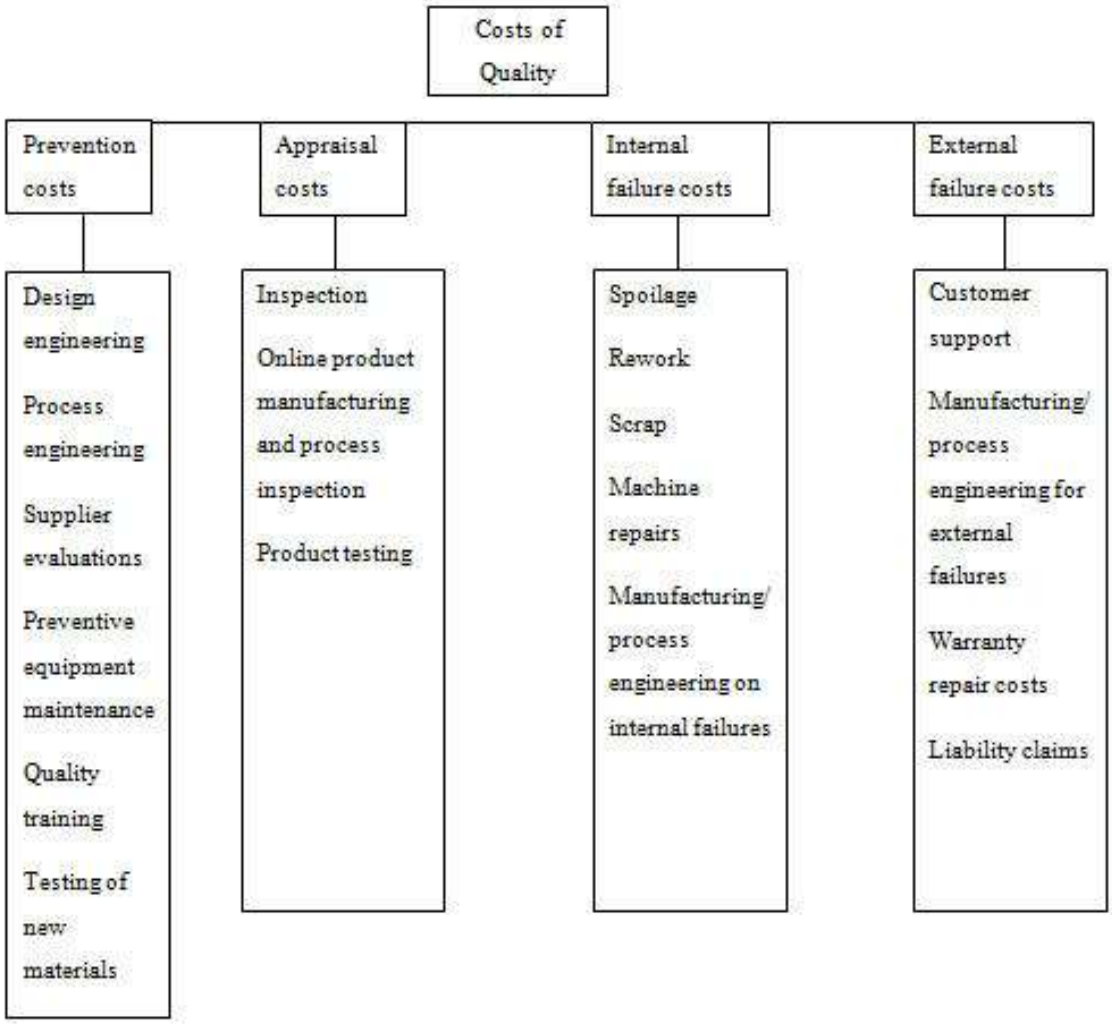


Figure 2-9 Horngren, Datar & Foster, 2003

2.2.10 Cost of delivery delays

To evaluate the time and the cost of delivery delays could be a complex activity. To understand the cost of a delay from a supplier, one must first understand the aspect that is called "cost of time".

Time could be considered and used as a strategic advantage (Horngren, Datar & Foster 2003) and can therefore be used as a method to gain an advantage. To lose this (possible) advantage could be dramatically for a firm, but very hard to evaluate and calculate. It is more likely that estimating the delay/stop in production would provide a better cost/benefit approach.

According to Horngren, Datar & Foster (2003), when further determining the cost of delays from suppliers, the key element is to determine the unused capacity. The unused capacity in a shop floor creates bottlenecks in the production line.

To determine the unused capacity that a delay causes, Value Stream Mapping (VSM) or Process Flow Charts (PFC) may be a useful tool. VSM and PFC help determining the internal production cost each product requires, and as a result of this, the opportunity cost could be calculated. (Kalsaas, 2009)

Ellram (1993) includes the following factors in delays: Follow-up the problem, expediting, higher freight costs, duplicated paper work and changing the schedule.

The external costs that delays from suppliers could cause are penalties from customers, lose future contracts and create a disadvantage when future price negotiation will take place.

Overall cost drivers from delays could for example be loss of trust in the supplier, the cost of changing suppliers and disposal costs of existing suppliers. These costs are the ones that are hardest to quantify.

2.3 Alternatives to TCO models

Ellram (1995) claims that there are several alternatives to a TCO model. Among these are the cost-ratio method and life-cycle costing. Another option is the Balanced Scorecard.

2.3.1 Cost-ratio method

Carr & Ittner (1992) describe a model which Ellram (1995) calls the "cost-ratio method".

Carr and Ittner cost-ratio model presents a definite, easy way to decide the costs of a supplier, and his products. A study performed by Carr & Ittner (1995) shows that Texas Instruments, by performing a TCO analysis found that the cost of a specific item was over 180 times the purchase price (The case is not described any further).

To adopt a cost-ratio model, there are several conditions that must be in place. The firm needs to have a Supplier Performance Rating System (SPRS), and the data that are put in this system must be correct. This creates the foundation of decision making by purchase personnel, and therefore is crucial to production firms which can spend as much as 70% of their turnover on suppliers.

The method proposed by Carr & Ittner, states that a Supplier Performance Index (SPI) should be calculated. This SPI should be calculated the following way:

$$SPI = \frac{\text{Nonconformance Costs} + \text{Purchase price}}{\text{Purchase price}}$$

Figure 2-10 Carr and Ittner SPI model

The non-conformance costs are calculated as a result of the SPRS, where the cost of delay and cost of quality are the main elements.

This way of calculating true costs of products gives a straight answer, which is easy for the procurement personnel to adopt into their decision making process. This evaluation

model helps manufacturers choose high quality suppliers, as well as it helps suppliers re-evaluate and improve their production and process if the data from the analyses are shared.

The weakness of this system is that it uses historical data, and therefore cannot be used for new suppliers. If a supplier is rarely used, one poor shipment could give a false image of the true picture. In addition to delays and poor quality, there are several factors that should be considered. Research & Development and product service capabilities are examples of this, and since these are hard to quantify, some systems would leave them out of the calculation.

2.3.2 Balanced scorecard

"What you measure is what you get" (Kaplan & Norton, 1992). This statement shows how important it is to have a carefully considered measurement system, whether it rates employees or suppliers. When using the Balanced Scorecard (BSC), the purpose is to measure more than just the rate of return or just the level or satisfied customers. It claims that, as the name says, there should be a balance between what is measured. When evaluating suppliers, the criteria that are evaluated must be well considered. When creating measurements, the focus should be on the vision and strategy of the company (as mentioned earlier), and use it to identify the main value drivers. After identifying those value drivers, it must be determined how they can be evaluated in the following manner: long term, short term, financial and non-financial measurements. It is important that what is chosen to be measured covers the total aspect of the business.

Examples for this could be: price, quality, innovation activity, willingness to collaborate, and responsiveness.

"The balanced scorecard shows *how* the results are achieved". It links the performance measurements together, and therefore displays a balanced picture. One very important aspect with this model is that it prevents sub-optimization in the interface between

suppliers and customers, due to the carefully considered measurements. As opposed to the TCO system, the balanced scorecard focuses also on the future, and does not only rely on historical data (Kaplan & Norton, 1996).

Despite the TCO models, the balanced scorecard does not try to quantify the non-financial measurements. It describes them as important, and considers them when evaluating suppliers. When using this way to evaluate, the true cost of a supplier will not be provided, but instead a subjective way of measuring suppliers. The presumption for using a BSC as an evaluation tool is that there is thorough knowledge of the measurement system, the supplier and the method.

2.3.3 Life Cycle Cost

Another alternative to the TCO approach is the Life Cycle Cost (LCC) way of calculating the cost of a product or supplier.

The LCC is calculated in advance of the project/expected period of cooperation with the supplier. This is more a risk management tool, to help managing decisions, as whether to initiate a project, or decide to make or buy. The risk is calculated/estimated using several different methods, which could include stochastic or experience data.

The LCC differs from TCO, as it is not used consecutively, but more as a guideline in the beginning of a relationship. If the relationship will carry on for a long period, the cash flow in the project will normally be discounted. TCO provides more a "snap-shot" of the current situation in the relationship with the supplier. LCC does not include the non-financial estimates, such as service level of the supplier, or his willingness to integrate, innovate or any of the other important aspects that occur in a supplier/customer relationship (Chapman & Ward, 2003).

2.3.4 Different evaluation tools

	Activity based costing	Cost-ratio	Total Cost of Ownership (Value based)	TCO (Dollar based)	Life cycle costing	Balanced scorecard
Considers acquisition costs?	No	No	Yes	Yes	Yes/no *	No
Considers non financial measurements?	No	No	No	No	No*	Yes
Quantify subjective measurements?	Yes	Yes	Yes	No	No*	No
Considers the discontinued cash flow?	No	No	No	No	Yes*	No
Easy to use	Yes	Yes	No	Yes	No*	No
Considers the consequence of quality/delays?	Yes	Yes	Yes	Yes	No/not directly *	Yes

* (When using the Life cycle costing method, the calculation is performed in advance. It is therefore impossible to correct asses the true cost of suppliers)

Figure 2-11 Comparison of supplier evaluation tools

2.3.5 Which evaluation tool is the most suitable for FMC?

In Figure 2-11, some of the more common evaluation tools have been evaluated. The evaluation criteria selected are a result of the more common values used in SPRS, the hypothesis and the task provided by FMC.
As mentioned earlier in this chapter, there is no standard way of calculating TCO. It is therefore difficult to find evaluation measures that capture the exact essence of a specific TCO model; instead, this master thesis has adapted some of the requirements that are considered as important.

Cost-ratio

To use the cost ratio method, a SPRS which rates the supplier with a SPI is necessary. If such a system already exists, the implementation of this method is the most suitable, as it would require the least change of the already existing system.

LCA/LCC

As described, the LCA/LCC is not a tool that could be used post transactions, and will not provide an answer to the research question.

Balanced scorecard

The balanced scorecard is a more modern evaluation method which does not focus entirely on the costs. It does not rely only on historical data and focuses more on the future. Therefore, for an innovative ETO firm, BSC could be a good choice.

2.3.5.1 TCO or ABC?

As mentioned in the research question, the intention of the TCO tool was to evaluate a supplier during a certain time. This way of using TCO, is in principal not different from using the ABC method. The purpose of ABC is, as mentioned earlier, to allocate the

(variable and indirect) costs to each product. If this is the purpose of the system, the ABC and TCO models can be used equally.

Conclusion

To further investigate if TCO is the most preferred way of evaluating suppliers, an empirical investigation must be conducted. In the following chapters, answers to the research questions will be given.

2.3.6 Theoretical framework

In chapter 2.1, the theoretical parts of this thesis are divided into four parts. In this framework, the three last parts are categorized in a different order, as an explanation for how they are used in this thesis, and how any firm could use them when going for an evaluation system.

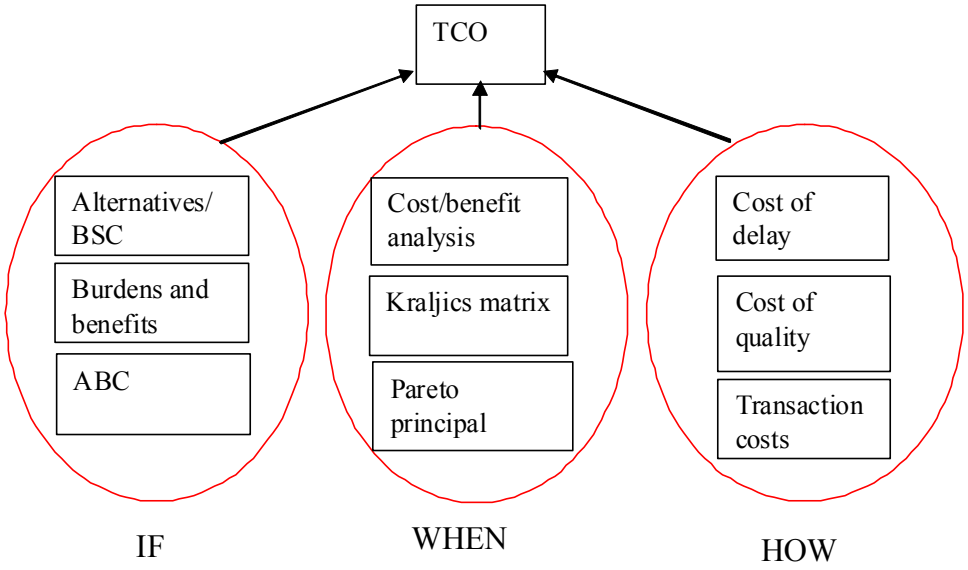


Figure 2-12 IF - WHEN - HOW theory

IF

The theories that fit the "IF" category are the ones that can be used to decide if TCO should be utilized in a firm, and if TCO is the right approach when it comes to evaluating/rating suppliers. It is based on what the literature and other case studies have experienced. ABC is in this category due to the large impact it has on TCO, as ABC could be vital when it comes to deciding, if TCO should be implemented. If a firm already uses ABC, the threshold of implementing TCO is much smaller. The "Burdens and benefits" category is with inputs from more case studies empirically investigated in chapter 6, and the alternatives (mainly BSC) are also considered in the empirical part. This part of the theory is important for this thesis, as it is directly linked to the research question. It is expected that the questions related to this part of the theory will be answered through questionnaires, examining the nature of FMC's business, and interviewing FMC employees.

WHEN

The "WHEN" category describes which factors to include if TCO analysis is used. These are the theories that describe when TCO analysis should be used, and when it should not be used. These theories are included in this thesis to help firms increasing the advantage of using TCO analysis, as they mainly describe when to use them, and to what extent. This category is not given much weight in the empirical part of the investigation, as the planned purchase of interest was already picked by FMC, as they already know, which suppliers they wish to look at. The Kraljic matrix is already in use in FMC, so the threshold of using it would be low. The "WHEN" category is as a tool to help personnel in Supply Chain Management decide when a TCO analysis should be performed. If the decision is to use another type of SPRS, this part of the theory would even there provide assistance when prioritizing, which cases to asses.

HOW

The "HOW" category describes the factors that are included when a firm has decided to use TCO, and for which transactions they have decided to use it. This part of the theory is

the one that could be more individual, as a result of what the firm wants to measure. It is the "HOW" category that will most likely consume most of the time spent on this thesis, it will as well consume most time when a TCO analysis is performed. This due to the fact that quantifying costs is time-consuming, the cost drivers are not constant, and that they are the ones that have an impact on the costs of a firm. Even if the research of this thesis does not suggest that TCO is the best way of evaluating suppliers, the cost of quality and cost of delay are still significant cost drivers, and an increased awareness of the effect these have, would still be valuable for FMC.

2.3.7 Summary

The purpose of creating this model was to show the relevance the selected theory has on this thesis. The theoretical contributions in the first parts of this thesis are directly linked to the main research question "*Is a Global Total Cost of Ownership Model appropriate for evaluating FMC Technologies' Suppliers*?" The existing theory shed light on this question, as well as the already conducted case studies help guiding this thesis in the right direction. The case studies serve also as an insurance for that the theory has relevance to the TCO subject in general, which will also be shown in the empirical part of this thesis.

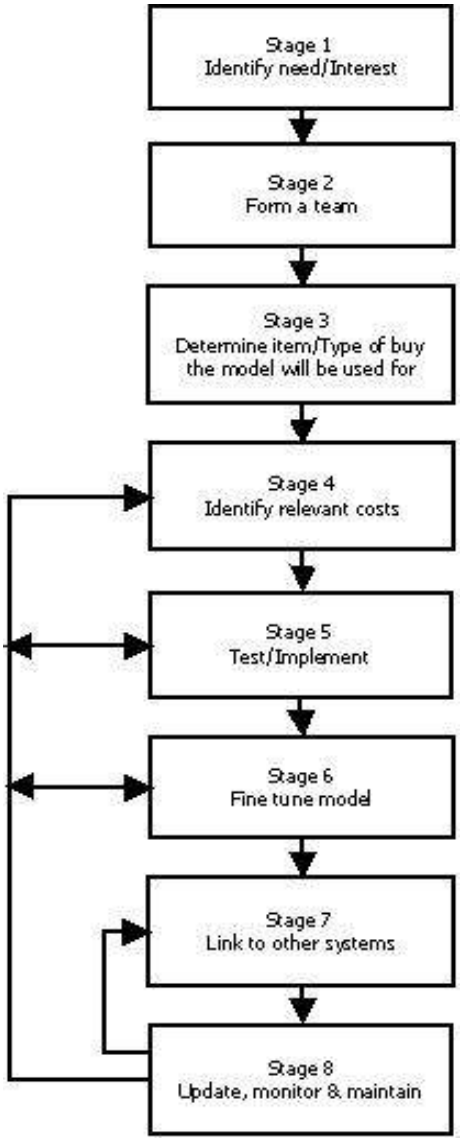
The four supporting research questions, which are derived from the main one, also use the theory, but in another fashion. They focus more on the "HOW" category, whereas the first question considers more the "IF" and "WHEN" category.

The parts regarding transaction costs and ABC are especially important, as this is what TCO mainly consists of, and will be referred to in the empirical analysis.

In chapter 4, there is mentioned that a theoretical contribution should derive from a study. From this thesis/study, we believe that the model which suggests how to use the "IF-WHEN-HOW" theory would, in addition to our result/conclusion, act as our theoretical contribution.

3 Development and implementation framework

Ellram (1993) has proposed a framework for development and implementation of TCO based on a case study of seven firms. This framework is divided into an eight stage process and is shown as a model in Figure 3-1. This master thesis will make use of this framework as a guideline for the development and implementation of a TCO model for FMC. Each step will be fitted to this master thesis. The main focus of this master thesis is the stages 1 through 4. The framework has been modified slightly to best fit this research. Stage 2 used to be stage 3 and vice versa. A brief summary of the process follows.



In stage 1 FMC identified that there is a need and interest of a TCO model in the organization. This interest was proposed as a master thesis, and the TCO team was formed due to this in stage 2. In stage 3 the identification of which type of buys this TCO model would be used for was determined. In stage 4 the development of the model started with identifying relevant and critical costs, as well as finding data to support these costs. This thesis will not go further than stage 4 due to the time period of the thesis and challenges met during the first four stages. However the stages 5 through 8 are included and explained in this chapter to provide a basis for potential further work on the TCO concept.

Figure 3-1 Framework for development and implementation of a TCO model

3.1 Stage one: Identify Need/Interest

The process of developing and implementing a TCO model must be initiated some way. In a company this initiative can come from external pressure or an internal need of such a system. The needs of companies are various, but in general the need is to understand that there is other cost related issues beyond price in managing the supply base of a company (Ellram, 1993).

3.2 Stage two: Form a TCO development team

Form a team inside the organization or bring in external resources. It is critical to identify a leader for the project who has ownership of the TCO. Acquiring employees from the different departments that are involved in use of a TCO model can contribute positively. In the sampling study conducted by Ellram (1993), the personnel involved in the TCO teams included purchasers, representatives from various engineering groups, internal customers, quality, and sometimes accounting/finance, marketing and other functions. The idea is that each representative has his/her own expertise and biases. Combining all these functions in a team causes visibility and awareness throughout the company, and the acceptance of a TCO concept increases.

3.3 Stage three: Determine the purchases of interest

The need in stage one is often related to specific purchases or suppliers. When working with and managing suppliers the need of a model that can handle more than just the purchase price can become prominent. If so, one supplier can be a starting point for the development. In some companies, as much as 80% of the revenue goes directly to the suppliers, and the top 20% suppliers are related to as much as 80% of the costs. In most cases the most beneficial purchases for further investigation with a TCO analysis would be some of or all the top 20% suppliers (Ellram, 1993).

3.4 Stage four: Identify relevant costs

This is where the real development work begins. This stage consists of several steps. First the identification of costs related to the need and purchase of interest must be established. The next step is to narrow down the costs elements to include only the costs that are important to the model that is developed. The third step is where the data related to the critical costs are gathered. The fourth step is to document, often in collaboration with step 3, the data sources (Ellram, 1993).

3.4.1 Cost identification

These costs can be identified in a number of ways. Methods such as brainstorming, examples from similar processes and case studies, examination of the acquisition process and relevant information from literature are examples of ways to get hold of this information (Ellram, 1993). Communications with employees involved in the processes related to suppliers are useful resources for the development of a TCO model.

3.4.2 Selection of critical costs

When identifying costs related to a supplier or a product it is likely to come up with a huge list of possible cost elements. Too many cost elements will make the TCO model too complex and not reasonably manageable. This step is where the cost should be narrowed down to a manageable amount. The already mentioned Pareto approach can be a way to help filter out the critical and significant cost elements (Ellram, 1993). This assumes that 20 % of the cost elements account for 80 % of the costs. When developing a general TCO model it is important to have in mind that the critical costs can vary among buys. A critical cost element for one commodity may not be critical for another.

3.4.3 Gathering and developing cost data

When the critical cost elements are identified, the next step is to locate where to get the supporting cost data from. This may not be a simple task (Ellram, 1993). It may require combining different sources of information, interaction with parties outside the team and developing new ways to get hold of important information. The gathering process may result in finding cost elements that are difficult to quantify because of lack of information and/or data. When such a problem is encountered it must evaluated if the particular piece of information is worth the effort. Maybe an alternative approach will get hold of the needed data, but is not necessarily 100 % accurate. Then a trade-off between the accuracy and the importance of the cost element must be considered (Ellram, 1993).

Data sources that can provide the required data include accounting records, special reports of item/service users, planning department records, quality assurance records, and so on (Ellram, 1993). In some cases it may be necessary to change or develop new methods for reporting data and information regarding suppliers and the processes that can be related to these.

3.4.4 Documentation

The findings related to the mentioned sections above should be recorded continuously. It is important in terms of systematizing the data for later use. Data that is transformed through formulas and algorithms should also be documented. Doing this consequently will make the work in the later stages much more efficient (Ellram, 1993).

3.5 Stage five: Test and implement the model

Now most, if not all, of the relevant data should be gathered and ready to be put to practice. All the gathered data elements should now be thoroughly reviewed by the team and it should be verified that they have the proper scope. If it comes up that important elements are let out, the team must return to the previous stage and gather the relevant

data. If inappropriate or uncontrollable data are identified at this stage, they should be deleted from the model. The costs should now be entered into the model and if further equations or formulas are required for calculating the costs, they should be developed at this time. It is also important to have in mind which data are actual costs and which data are based on "assumptions" or educated guesses. In most cases the verified data should be given more weight (Ellram, 1993). Documentation of the following factors should by now have been recorded:

- All data sources.
- Whether the data is based on assumptions or actual, historic data.
- Any equations and formulas which were used for calculation of individual data elements.
- The results of the model calculation.

3.6 Stage six: Fine tune the model

Stage five can be considered a test run of the model, where the individual elements were analyzed according to the data and the equations. This stage involves multiple phases, including analysis of the model results, incorporation of changes, and identification of the TCO scope. Before going any further the team must answer positively to the following questions; do the big picture results seem reasonable? Are the critical elements included? Is the team comfortable enough to explain the results to others outside the team, including top management? When all potential errors are weeded out, the model is ready to serve as a decision making tool. In this stage the process should be evaluated and documented. This can save considerable time and effort in future TCO modelling (Ellram, 1993).

3.7 Stage seven: Link TCO to other systems

There are three systems the firm should consider linking to the TCO model; the firm's supplier monitoring system, the firm's training and education programs, and the firm's computer systems. By linking the TCO to e.g. the firm's ERP system there may be an opportunity to pull TCO reporting data directly from other systems. The model would be easier and more convenient to handle when large parts of the model are automated (Ellram, 1993).

3.8 Stage eight: Continue to update, monitor and maintain the system

The TCO system needs to be monitored and re-evaluated on a continual basis, as every system (Ellram, 1993). Are the costs that were relevant, still relevant? Does the system still provide the right scope? These are questions one can ask at this stage.

4 Method

The research of this thesis is based upon a methodology taken from Kasanen, Lukka, & Siitonen (1993). The methodology is called constructive research and is defined as: "managerial problem solving through the construction of models, diagrams, plans, organizations, etc"(Kasanen et al, 1993). The methodology is illustrated in Figure 4-1. It is based on that research and theoretical knowledge is combined to solve a relevant problem. In this case to investigate if a general TCO model can be adapted globally by FMC.

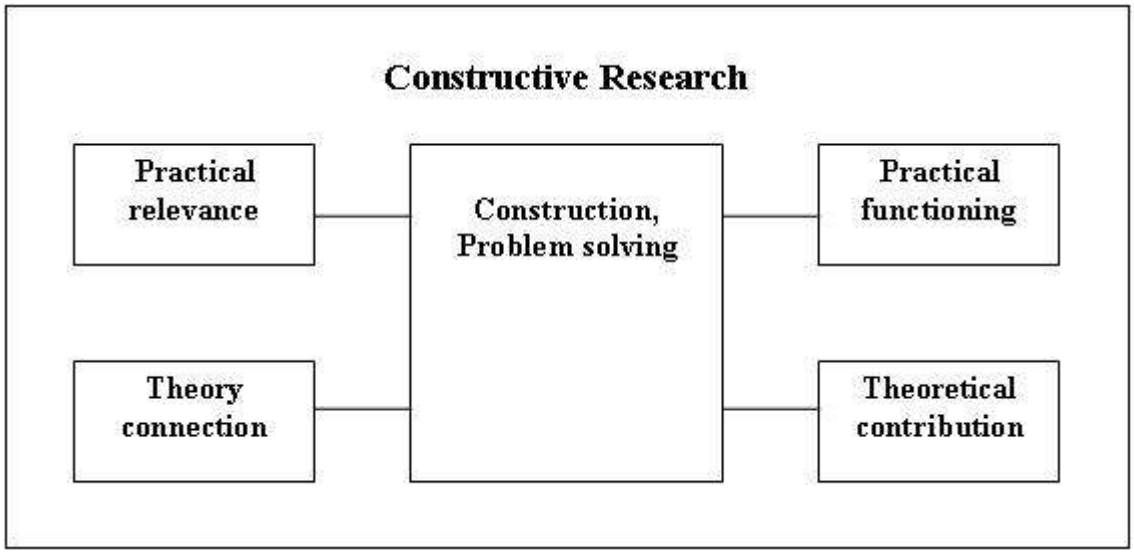


Figure 4-1Constructive Research

Kasanen, Lukka, & Siitonen (1993) propose a six step procedure for the constructive approach:

- Find a practically relevant problem which also has research potential.
- Obtain a general and comprehensive understanding of the topic.
- Innovate, i.e., construct a solution idea.

- Demonstrate that the solution works.
- Show the theoretical connections and the research contribution of the solution concept.
- Examine the scope of applicability of the solution.

This thesis can be related to these six steps, the problem the thesis is aiming to solve is proposed by FMC. The problem is stated as a research question in chapter 1 and is of practical relevance and will hopefully contribute positively in future procurement processes at FMC. The theoretical fundament for this research is presented in chapter 2 where relevant literature is thoroughly examined. The focus of the theory is on what exactly the TCO concept implies and examples of existing TCO models for purchasing that are relevant to this research. The method for the problem solving will be examined in this chapter. The collected data from interviews and questionnaires will be examined in chapter 6. Based on the latter a proposal for FMC will be presented in chapter 7. A review of our solution to this problem and the reliability is examined in chapter 7. The theoretical connection between the research and the theory has continuously been ensured throughout the developing process of the model. The scope of applicability of this research will be examined in chapter 7.

4.1 Elaboration of the research questions

The research questions are the foundation of this master thesis and create the platform of the future work. Because this master thesis has a searching approach the research questions are likely to be modified as the process evolves. Due to these modifications the work in progress has to be continuously adapted to the new findings. This master thesis has one research questions that it intends to answer. Additionally it has been developed four questions that will assist in answering the research question.

"Propose a Global Total Cost of Ownership Model for FMC Technologies' Suppliers" was the original task provided by FMC.

As the work on the thesis carried on, several changes of the first intended research were done. The first intention with the model was to create an easy to use tool, which did not require much depth insight in the supplier activity. It was supposed to be a tool that could be used by anyone, where one push of a button should have given the correct answer.

This intention was changed, as it was not possible to create one model, which was comprehensive, thorough and easy to use. The next goal was to create a tool that should be used by Supply Chain Analysts (SCA), and Supplier Development Engineers (SDE). This would make the task easier, as some presumptions of Supply Chain Management/Purchasing would be required from the personnel that would use a potential TCO model.

After assessing the theory, and starting the empirical analysis, several difficulties and barriers came up. Among others, the discussion if TCO is the preferred way of measuring suppliers came up. In the starting phase of the project, it was presumed to be. As a result of these changes, the main research question became:

1. *Is a Global Total Cost of Ownership Model appropriate for evaluating FMC Technologies' Suppliers*?

Further, as a continuum of the main research question, other questions were created.

- *Investigate and describe TCO models (if any) used in FMC locations*.

The described theory and the methods used in estimating the indirect costs will be the foundation when evaluating the already existing methods. What is the foundation of these models? Is there any need for another TCO model in FMC?

- *Which factors are considered in general TCO models described in the literature*?

If there are any general TCO models, a denominator of the cost drivers would be useful in our further creation. Why are these cost drivers considered? Are they relevant for the industry FMC represents?

- *How do the FMC locations gather the necessary data that is used in TCO models (if any other models exist*)?

Is the Enterprise Resource Planning (ERP) system SAP used, or is gathering of data done with any other system? Are subjective matters and "gut-feeling" used? Is there any other way FMC can do this, which would create an easy access for the analysts that perform TCO analyses?

- *How can cost of Non-Quality and Delivery delays be considered*?

To ensure a proper and credible result from a TCO model, the input must be correspondingly. The theory describes certain ways of calculating the "cost of quality", some parts of it may be performed with Value Stream Mapping (VSM) or Process Flow Charts (PFC). To be able to correctly assess these costs is a huge barrier to overcome when creating a TCO model.

If the answer to the main research question is negative, TCO is not the best way to rate suppliers, the other research questions are developed in a way that the answer they provide would still be valuable.

It should be noticed that the main question has received the most attention, and the others are, by us, considered to be subordinate.

4.2 Case study as a research strategy

Case study research aims to give an understanding of a complex issue or object. It can expand the experience or add strength to what is already known through previous research. This method of research has been adopted by social scientist in particular, and

they have used it for examination of contemporary real-life situations (Soy, 1997). Robert K. Yin (1994) defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used. It benefits from the prior development of theoretical propositions to guide data collection and analysis (Yin, 1994).

An important note is that the case study should not be confused with "qualitative research". Case studies can be based on a combined use of quantitative and qualitative evidence (Yin, 1994).

In some situations specific strategies have a distinct advantage, and for case studies it is when one wants to answer a "how" or "why" question that is asked about a contemporary set of events over which the investigator has little or no control (Yin, 1994).

4.3 Methodical approach

There are two well used strategies for methodical approaches in researching, qualitative and quantitative method. The objective with these methods is to provide a better understanding of the research questions one wants to answer (Johannesen, 2004). This chapter starts with a concise explanation of the two methods, followed by the selection of the methodical approach.

4.3.1 Qualitative methods

The characteristic of the qualitative method is that it considers "soft data". Examples of qualitative methods are interviews, direct and participant observations and document analysis. The purpose of the qualitative methods is to provide an understanding of the phenomena or the relations that are examined. Qualitative methods are more flexible and adaptable to changes in the research process, in contrast to the quantitative method. This allows a richer and more detailed description than the quantitative method. It is the

researchers own review and impressions that affects the extent the information influences the research questions. One weakness with this method is that the gathered data does not provide the basis for generalizing. The strength on the other hand is that the method provides the opportunity for and understanding of the phenomena and the relations thru a thorough and comprehensive presentation, and also openness and flexibility in work process (Johannesen, 2004).

4.3.2 Quantitative methods

The purpose of quantitative methods is to gather data that are quantifiable, numbers and data that are measurable. To analyze the gathered data, it will be counted and statistical tools are applied. When conducting such methods, it will in many cases be desirable to get generalized statistical knowledge of the studied field. But in some cases it can not be done due to lack of representative data. The weakness with quantitative methods is the lack of opportunities for thorough and detailed descriptions of the phenomena that are studied. This can cause implications when describing social relations. On the positive side, the strength of quantitative methods is that they give the opportunity to draw specific conclusions, if the collected data is representative.

4.3.3 Methodical triangulation

In social sciences, triangulation is often used to indicate that more than one method is used in a study with a view to double (or triple) checking results (Wikipedia). In this case it implicates a combination of qualitative methods and quantitative methods. Case studies are not limited to the use of just one of these conditions. Instead, they are based on any mix of qualitative and quantitative evidence (Yin, 1994). When combining these methods it gives the opportunity to study the results form different angles. And if the two methods draw the same conclusion they can provide a more reliable result that can lead to new interpretations, more accurate descriptions and more comprehensive explanations. Methodical triangulation can be used in three different ways; a qualitative follow-up of a

collection of quantitative data, qualitative preparation of a quantitative data gathering or make use of both methods simultaneously where they shed light on each others result.

After identifying the data requirements and the methodical approach for the research, the next step in the process is to select a method for data gathering.

4.3.4 Method for data gathering

When gathering data Zikmund (1997) distinguishes between to types, primary data and secondary data. The primary data is what the researcher comes up with during the study of an objective or work on a project. The primary data is usually more specific and accurate than the secondary data and can be tailored to a greater extent to fit a unique project. A disadvantage with primary data is the effort and time it requires to gather the information. Retrieval of primary data is done through for example interviews, surveys, observations and analyses of financial material. Secondary data is retrieved by other people and can be found in literature, research reports and on the Internet. Secondary data is easier to retrieve, but sets stricter requirements for evaluation of the relevance of the information. And in which degree the information is up to date. The advantage with secondary data is that it prevents the researcher doing something that was already done.

4.4 Case study approach

According to Johannesen (2004), the research question is the deciding factor for which approach to consider. After discussions with employees at FMC it became clear that relevant data for answering the research questions is spread among different systems and people, and the data provided may not be as accurate and complete as needed. The research question aims to answer if TCO is appropriate for FMC. To fully answer this question it has to be investigated why it may be appropriate or why not. Case studies are the preferred strategic approach when "why" or "how" questions are being posed, when the researcher has little control over events, and when the focus is on a contemporary

phenomenon within some real-life context (Yin, 1994). This master thesis is on the basis of the latter regarded as a case study and will be based on a triangular approach with simultaneously use of both qualitative and quantitative methods, as described in chapter 4.3.3, to obtain as high reliability and validity as possible. This thesis also aims at verifying the relevancy of the quantitative data that can be used for supplier evaluation found in FMC's ERP system, SAP, today. This requires that qualitative and quantitative data are compared for their reliability and validity. The data provided for this thesis is based on interviews, questionnaires, FMC's enterprise resource planning system (ERP); SAP and literature on the subject. The qualitative and quantitative data in this research can to some degree be divided into what this thesis aims to answer. The initial stage of the development process is where in this case, the qualitative data is gathered. This is data that contributes to shape and design the possible TCO model that could fit the organization and what it is going to measure. In this part both primary and secondary data are gathered from interviews, surveys and literature.

4.5 Reliability and validity of research work

Below follows a brief explanation of the terms reliability and validity, and an assessment of the latter in this thesis.

4.5.1 Reliability

Reliability is an important and fundamental factor for all types of research. Key questions that are included in the process are which data the research relies on, how these data have been gathered and in which way have the data been processed? One way to ensure the reliability of the performed research is the "*test-retest-reliability*" method. This is done by performing the same test of the phenomena two times. Another method to ensure reliability can be done by several researchers performing the same research at the same time (Johannesen, 2004).

4.5.2 Validity

Validity refers to which degree the data collected is representative for the questions one wants answered in the research (Johannesen, 2004). While reliability is related to the accuracy of the actual measuring methods, validity is concerned with the research's success at measuring what the researchers want to measure. Reliability is a prerequisite for validity; if the data are not of high relevance to the problem, this will imply that the validity is low. In research it is common to distinguish between several forms of validity. Among these are construct, internal and external validity (Yin, 1994).

Construct validity is if the data provided to answer a question is valid. The point is that the sources one might use for answering a research in all cases would be right. A way for strengthening the construct validity is to use multiple sources of evidence (Yin, 1994).

Internal validity means that a statistical correspondence can also prove to be a causal connection. If the research has a high internal validity this means that the research is carried out in such way that a determined correspondence between two variables can possibly be a causal connection. Though, internal validity is only a concern for causal (or explanatory) case studies, not exploratory and descriptive case studies (Yin, 1994).

External validity means that the results of the research are suitable for generalization on the basis of the selection of the population, or that they are transferable to other contexts. To increase the external validity one can perform the same research in other contexts or in another point in time (Johannesen, 2004).

5 About FMC Technologies

This chapter will briefly describe the history and business units, operating locations, the core business and the business concept of FMC Technologies, Inc. that is subject of this Master Thesis.

5.1 FMC Technologies

FMC was founded in 1884 by the development and manufacturing of a spray pump that was used in the fight against scale insects. The company grew to become the world's largest manufacturer of agricultural machinery and equipment by the mid 1930's. Today FMC is divided in to two separate companies; FMC Corporation (chemicals business) and FMC Technologies. FMC Technologies Inc is a global diversified corporation and the leader within the oil and gas equipment and service industry. FMC employ approximately 11000 people spread among 33 manufacturing facilities in 19 countries.

FMC Technologies supplies among others equipment for oil and gas exploration and production for onshore, offshore and subsea production systems. The company is divided into several business units that are shown in Figure 5-1.

FMC Technologies support subsea development with their subsea systems in several regions all over the world such as, Gulf of Mexico, West Africa, North Sea, East Coast of Canada, Brazil and Asia.

Figure 5-1 FMC Technologies business units (FMC Intranet)

FMC Kongsberg Subsea belongs to the business unit Subsea Systems along with the FMC locations in Houston, Rio de Janeiro, Singapore and Dunfermline**.**

5.2 About FMC Kongsberg Subsea (FKS)

FKS is the leading subsea systems supplier in the industry and supply innovative solutions for field development, production systems, subsea drilling and completion systems and control systems. FKS also provides product engineering, customer support, on-site service and maintenance, spare parts delivery and customer training.

Originally FKS was the Oil division of Kongsberg Våpenfabrikk (Kongsberg Weapon Factory) in Kongsberg, Norway. It was in 1986 renamed Kongsberg Offshore AS, and

just one year later, in 1987 acquired by Siemens. In 1993 Kongsberg Offshore AS was acquired by FMC, and in 2000 they changed the name to FMC Kongsberg Subsea AS.

Key areas of product and system expertise are:

- Subsea Drilling and Completion Systems
- Subsea Field Development
- Subsea Production Systems
- Subsea Control Systems
- Subsea Tie-In Systems
- Subsea Processing
- Subsea well maintenance

5.3 Products

FMC subsea production systems are shown in Figure 5-2 (FPSO is not a product of FMC). The included products are tie-in and flow-line products, subsea trees, manifold, drilling systems, control systems, completion and workover riser systems and well systems.

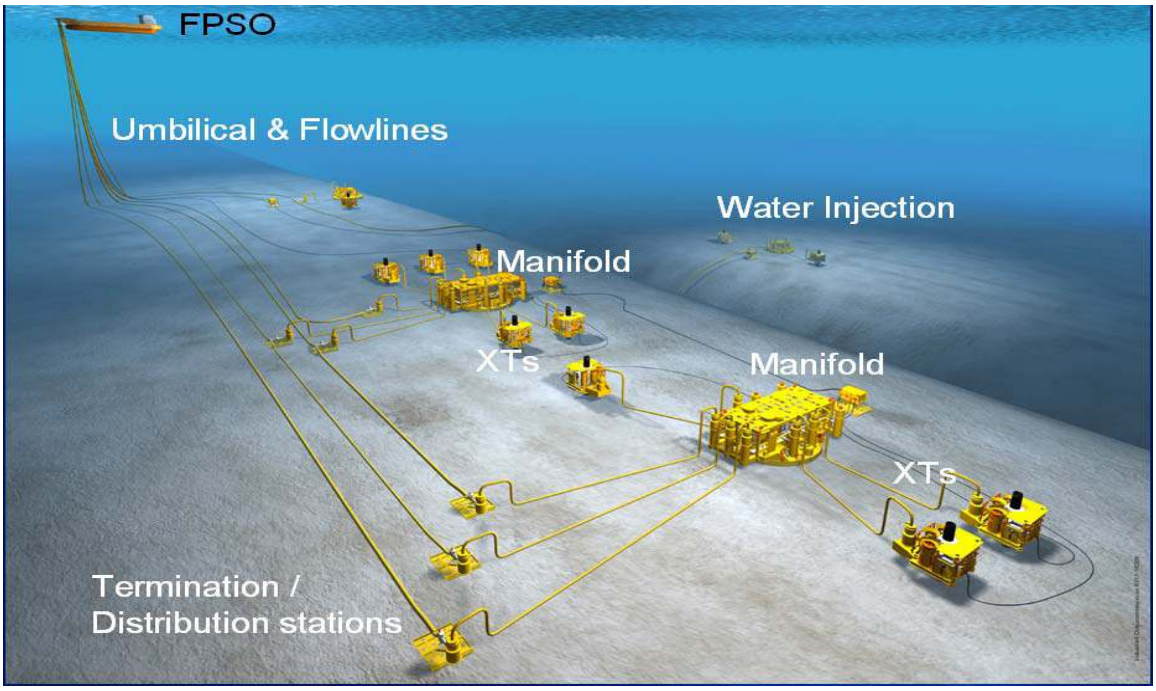


Figure 5-2 FMC subsea production systems

6 Empiric analysis

FMC wants to create a global TCO model that can be used for evaluating and comparing key suppliers at a periodical basis. The main purpose is to improve the understanding of the total cost concept throughout the organization, improve the basis for negotiations and simplify the process of choosing the over-all cheapest supplier.

This research process has been done according to a framework proposed by Ellram (1993), and is described in chapter 3. Due to the challenges met in the data gathering process, the stages 5 through 8 are not worked out by this master thesis. For future work on this subject this thesis recommends to follow the procedures explained in the framework because it provides a clear and understandable layout for the development and implementation process of a TCO model. The first four stages of the process will be thoroughly reviewed in this chapter.

6.1 Stage one: Identify Need/Interest

The sponsor of this master thesis, the Global Subsea Sourcing Director at FMC Technologies, has acknowledged that there are costs beyond the item price that need to be accounted for when dealing with suppliers. And too often, it is the item price that underpins the decision whether a supplier is selected or not. There are processes within FMC that register quality, on-time-delivery and logistic aspects of suppliers, but the data is insufficient and not combined in a way that they can be use "out of the box" for evaluating the different performance aspects of a supplier. The goal with this master thesis was to do a thorough investigation of the processes of interest and identify relevant data that would contribute to an adequate global TCO model.

This master thesis was initiated by the Global Subsea Sourcing Director and the work has been supervised by the Global Supplier Development Engineer. For a TCO concept to be successfully implemented and adopted in a large organization such as FMC

Technologies, the literature according to Ellram (1993) states the importance of support from Senior Management. A start can be to include some TCO related substance in the sourcing strategy of FMC so that the price orientation of purchasing moves towards a total cost understanding.

6.2 Stage two: Form a TCO development team

The interest and need of a TCO model in FMC was proposed as a subject for a master thesis. The team was formed and consists of the authors of this thesis. In the framework described in chapter 3, proposed by Ellram (1993), it is recommended that the team consists of employees from different relevant departments of the organization. Even though the latter is not the case for this thesis, throughout the work key personnel from different locations and departments has influenced the result of the thesis by contributing in informal conversations and by answering surveys.

6.3 Stage three: Determine the purchases of interest

The purchase of interest for the TCO model is directed against the major suppliers. Because there is associated some work with carrying out an analysis with this model it is not likely to be cost beneficial to apply this analysis to smaller suppliers. As the already mentioned Pareto principle tells, that about 20 % of the suppliers account for about 80 % of the costs, it is natural to aim at the major suppliers. However, if a TCO model is fully automated and linked to an organization's system the cost of performing an analysis would be lower and would open for possibilities to include a wider spectre of suppliers.

The initial idea for carrying out this thesis was to create a case scenario based on a selected strategic supplier. This supplier is more thoroughly described in chapter 6.3.1. The purpose of the scenario was to keep the relevance and validity of the result within controlled boarders, and also compare the result of the TCO model to data provided by the Commodity Manager who had worked closely with this supplier over several years.

The purpose of the comparison was to verify to a certain degree if the data provided by the TCO model was relevant and valid. Unfortunately the Commodity Manager could not provide the desired data because the data required too much time to gather. However, it was acknowledged that getting data that would contribute to an adequate TCO model was complex and would require a laborious work. Though, the Commodity Manager provided good information and guidance on relevant cost drivers to include and possible ways to identify relevant data for the further work with this thesis, as will be gone through in chapter 6.4.

In Ellram's paper (1993), she describes this method (performing a pilot study on a supplier), as a good way to implement TCO in a firm. When selecting the purchase of interest, certain criteria should be followed.

- The firm spends a relatively large amount of money on that item.
- It should be a component
- It should be regularly purchased
- The firm expects there to be large unidentified transaction costs associated to the supplier,
- There should be an opportunity to have an impact on the transaction costs, via negotiating, changing suppliers, or improving internal operations
- Those who are using the item should contribute when gathering data.

The mentioned supplier fits several of these characteristics. If time would have been spent on this supplier, and it would have been possible to sketch up a Process Flow Chart (PFC), it is likely that a proper result would have been provided.

6.3.1 A Strategic Supplier

This vendor delivers Subsea equipment to FMC. Even though there are some other vendors within the same commodity, FMC buys their equipment from this particular supplier. Therefore, this supplier is regarded in the Kraljic matrix, up in the right corner area (according to the Commodity Manager), which is the strategic product category. This is also in accordance with the theory.

As a result of the importance of this supplier, it is understood why FMC wants to keep a close relationship to them.

After talking with the Commodity Manager, the impression was that this supplier requires a lot of attention, follow up and expediting, and this is the reason for their very good OTD performance. It is therefore suspected that the indirect costs this supplier requires are much higher than what it appears to be.

The reason why a high OTD performance is important for this particular commodity is that these components are one of the first items used in FMC's production line. If the product is delayed, several measures have to be performed such as ad-hoc planning. A replica, which imitates the product, could be created and replaced when the original arrives, or reorganization in the shop-floor could be performed. This is a non-value adding activity and should therefore be avoided.

The main cost drivers from this supplier are estimated (by the Commodity Manager) to be quality, OTD, product documentation and expediting.

6.4 Stage four: Identify relevant costs

The process of identifying relevant costs for a TCO model was done through several approaches. The theoretical contribution was examined for cost drivers that could fit to the need of FMC. There were performed several conversations and informal interviews with key personnel in FMC, and a survey was sent out to the different FMC locations.

6.4.1 Cost identification

By looking at the relevant literature of the subject, case studies performed in this literature and input from key personnel at FMC, a list of potential cost drivers was shaped. A questionnaire was also sent to the different FMC locations that aimed to get an answer if there already were existing TCO models in use and which cost drivers are included in these models. The questionnaire also requested a response to the questions which cost drivers may be relevant for a future TCO model. The responses from this questionnaire are provided in Figure 6-1 and Figure 6-2. The answers from this contributed to a list of possible cost drivers to include in a potential TCO model. Because this model was to measure a wide variety of global suppliers the aim was not to be too specific in the beginning, and eventually narrowing the list down step by step. As stated in the literature it was found that the cost of quality and cost of deviance from on-time delivery (OTD) acted as the major contributors to the Total Cost of Ownership.

6.4.1.1 Matrix of the different cost drivers of the FMC locations

The matrixes shown in Figure 6-1 and Figure 6-2 provide the result of the initial questionnaire that was sent to the different FMC locations.

Location 1	Location 2	Location 3	Location 4	Location 5
Quality	Quality	no feedback received	does not have a TCO model	does not have a TCO model
OTD	OTD			

Figure 6-1 Cost drivers FMC uses in their TCO models

Sources for the questionnaire:

The questionnaire was sent to individuals who are positioned in several strategic sourcing positions. These positions are Strategic Sourcing Managers, Global Commodity Managers, Supply Chain Managers and Supplier Development Engineers.

It is presumed that these individuals have a good understanding of the purchasing/logistic process in their locations, and also understand the value of having a functioning TCO model/SPRS.

Figure 6-1 shows the current situation in FMC. Surprisingly FMC has already developed, implemented and adopted a Supplier Rating System (SRS). This SRS is based on the value-based TCO model that is described in chapter 2.2.8 and is used in two locations. As seen in the figure, the already existing supplier rating models include Quality and OTD as cost drivers. This is in accordance with the existing theory on the subject. Even though FMC has another TCO model (proposed by a consultant), it is not in use. The models that the two locations use are almost similar.

In Figure 6-2, the cost drivers that some FMC locations wish to implement in a TCO model are listed. These cost drivers are provided without any more, according to our knowledge, consideration of the impact they have on the TCO (high/low).

Location 1	Location 2	Location 3	Location 4	Location 5
Managing suppliers	no feedback received	no feedback received	no feedback received	Development cost
Inventory related				(Third party) inspection costs
Transportation				Quality
Risk element				OTD
Quality				
OTD				

Figure 6-2 Cost driver wish list from the different FMC locations

One aspect to consider when evaluating these cost drivers is the impact they actually have on TCO, and the impact they seem to have. It is natural for a person who spends a great deal of time expediting suppliers to feel that this is one of the main cost drivers. This mainly due to the time he spends on the supplier.

This could be the case for those suppliers who have a sufficient OTD record, but in those cases where there is a lot of room for improvement, expediting would most likely, be a minor cost driver measured as percentage of the costs related to the purchase. Expediting is, on the other hand, one of those costs that are more "definable" in the TCO model, and should therefore be easier to estimate and include.

6.4.1.2 Response on questionnaire

The initial questionnaire was sent to a total of 11 persons in FMC, whereas four answers were received. There was sent one follow up mail. The relative small amount of feedback received, could indicate several things:

- Employees in FMC do not believe there are any uses for TCO in FMC.
- Employees have a very busy schedule, and do not prioritize to answer these questionnaires.

- Employees do not care about TCO.

The reliability of the responses to the questionnaire is by this thesis regarded high because of the relevance the subject TCO and supplier evaluation have for the job they are performing on a daily basis. The validity of the feedback is discussable. Only getting feedback from four of the participants could indicate that the rest does not believe TCO is an appropriate method for evaluating suppliers in FMC. Most likely it is a combination of the points made out above. The reason for the poor feedback is not further investigated, but what it may indicate will be taken into consideration when concluding this thesis.

6.4.2 Selection of critical costs

This section will consider the critical cost drivers that are believed to be important in a potential TCO model, as well as why they are considered to be important.

6.4.2.1 Background

When selecting and choosing cost drivers to be used in a future TCO model there has been gathered information throughout the organization and a secondary questionnaire to key personnel was sent. The sources are FMC employees, such as Commodity Managers, Managers in Strategic Sourcing or Supplier Development Engineers. This survey aimed to get specific answers on the question which cost drivers would be critical to include in a TCO model, if a TCO model would be a usable tool in FMC for evaluating supplier performance, how much time these people were willing to spend on a TCO analysis, suggestions to where to find data for these cost drivers, how precise the TCO model should be, and if there is a defined sourcing strategy in their location. The respondents were asked to rate the importance of those cost drivers that came up in the initial survey. The rating is shown in Figure 6-3. The result of this survey will be discussed throughout this chapter. There were only 3 respondents to this questionnaire.

	Participant 1	Participant 2	Participant 3
Cost of Quality	1	1	1
On-Time Delivery	2	2	2
Transportations cost	3	4	5
Expediting cost	4	5	4
Inventory related cost	5	6	6
Travel costs for supplier visits	6	7	8
Supplier Development costs	7	3	7
Third party inspections was added by one of the participants and ranked third			3

Figure 6-3 Rating of critical cost drivers

The result these employees came up with, were quality-checked against the findings in the theory. The people who provided the information about the cost drivers are experienced personnel who work with suppliers on a daily basis. All of the involved persons work with global aspects, and therefore represent a wide range of expertise. When selecting these costs, an evaluation of how obtainable they are and how much impact the different costs would have was performed.

6.4.3 Gathering and developing cost data

The theory states that there are no standardized processes on how to gather and develop cost data. Because various companies have different methods and routines for which data to register and how to register this data, it is not hard to understand that this is a highly individual process for each company. Even though the same ERP system can be used by two different companies, the system may be so complex and tailored for exactly the individual processes involved in each company that the approaches for gathering data are rarely done similarly. However, the theory gives some examples of where one could find sources for data; the firms accounting records, special reports of item/services, planning department records, quality assurance records, as well as consulting employees working within the field that is studied and developing new information. It is also stated that if

some information is hard to acquire, one must decide whether the particular information is worth the effort.

FMC uses the ERP system SAP. It is in SAP all data regarding the daily operations are or should be registered. For a TCO model to be functional and practical the data provided must be easily obtainable. The respondents of the survey stated that the amount of time they wanted to spend on a TCO analysis on a monthly basis was between 5 and 24 hours. Therefore the SAP system should be the main source of information for a TCO model. In a well implemented and properly adopted SAP solution all information is available to the entire organization. The process of registering information and data into the system should also be standardized throughout the organization.

For this thesis, the gathering and development of data for the selected critical cost drivers proved to be challenging. In the survey sent to the different global FMC locations they were asked to respond on how to obtain relevant data in SAP for the development of a TCO model. None of the respondents could give a concrete answer where to find any kind of relevant data in SAP. Conversations with FMC key personnel mostly led to the same answer. The reason for this is mainly because all costs are directly related to projects, and not linked to specific suppliers.

In this chapter, each of the critical cost drivers will be viewed separately and proposals for where to find data or develop data to quantify these costs will be suggested. In some cases the relevant data is relatively easy to acquire, in other cases the required data is not possible to obtain from the currently available information sources. **A very important notice is that if the result of a TCO analysis is to be reliable and valid, the data stored in SAP must be accurate and correct. The routines for registering data into SAP must follow only one standard, and there must be no room for personal preferences when registering data.** As of now there are weaknesses related to SAP, where employees who register data have the opportunity to manipulate the information they provide. This can result in that incorrect data are registered into the system. The

following is an example provided by a Commodity Manager in FMC: A project needs a part for further progress and engages a purchaser to make an order to the relevant supplier via the Material Requirement Planning (MRP) system. For some reason the purchaser makes the order too late or the request from the project comes too late through the system so that the order won't make the delivery date required by the project. The purchaser knows that the supplier can not provide the parts when required by the project, but still registers this date in SAP. He assures the supplier that there is no problem related to the "late delivery". This way the purchaser appears to have done everything right, but the supplier appears to deliver too late. This situation may occur because purchaser's performance is measured on terms that are possible to manipulate.

For this thesis it has to be assumed that the data provided by SAP is accurate or at least close to accurate.

6.4.3.1 Cost of quality

Cost of quality is, as mentioned, regarded as a major cost driver in the literature. Also the respondents to the questionnaire ranked cost of quality at the top. Quality is not a cost driver itself, but a cost element, with underling drivers such as man-hours, third party inspections, opportunity costs and delay caused by quality failure. It is according to the theory and the hypothesis one of two main cost drivers, and in the existing SPI model (Appendix A) it is one of two elements. It is therefore conclusive to consider cost of quality as a considerable cost driver.

This thesis will focus on the quality defects that are caused by the supplier. The failure can be revealed on arrival of the product or later during the production process. A failure on equipment can even appear several years after it has been set in operation by a customer.

As the information from the respondents of the questionnaire returned, it became evident that the term cost of quality was not unambiguous in FMC. The cost of quality, as earlier

mentioned in the theory, contains prevention, appraisal, internal and external failure costs. As a result of the feedback, it could look like quality cost in FMC is mainly considered as products of poor quality. This is further underlined by the already existing SPI based model described in chapter 6.7, which measures poor quality of products delivered from suppliers.

Internal Failure Costs

Poor quality products are expensive for FMC. Though, it is one of the cost drivers that should be easier to quantify if the required data is provided. Calculating the cost of poor quality is not done by FMC today, but in 2001 it was performed some work on putting a price on quality notifications (QNs). (Example of this is received from a Senior Product Quality Assurance Engineer at Kongsberg).

QN

QN (Quality Notification) is the term FMC uses in SAP to report Non Conformance Reports (NCR). There are different notification types in SAP, depending on the nature of the NCR. Some report vendor errors, some report internal errors and others report customer complaints. Until now this is included in a QN; a description of the defect, the product and the supplier, if the product needs to be scraped, reworked at FMC, or reworked at the supplier, which persons are involved in the process, when the defect appeared and when it is required to be finished, as well as the actual finishing date. The latter is in accordance with the theory that describes relevant factors that can contribute to calculate cost of quality.

As of today the estimation of the cost of QNs in FMC is extremely challenging, due to the lack of data and standardized registration processes. This thesis has received indications that one FMC location has started a work related to more precisely estimating the cost of poor quality. As of now, according to the QA department in another FMC location, each QN must be treated separately, as each QN is more or less unique, and

therefore requires different amounts of resources. This is to ensure that the correct cost is transferred into a TCO model. Included in these QNs are the opportunity to allocate costs to spoilage, rework, scrap and the lost opportunity cost. This is by now only done in one FMC location. Otherwise, the costs related to a QN in FMC today only represent a fixed administrative cost. For a cost to function as a cost driver in a supplier evaluation tool it has to vary as a result of the complexity and the work put into that process. It could be indicated that the process of estimating the cost of a QN is not a prioritized task, as the data we received on this was performed in 2001.

For this thesis there is the data provided in a QN that is of high relevance in calculating the cost of quality, but some important information is missing, such as time spent by the various employees that are involved in the QN. For calculating the cost of quality within a reasonable range of accuracy this information is vital. For the calculation it must be assumed that all instances where poor quality occurs will generate some additional costs. This can for example be overtime payment due to extra work to get back on schedule or late deliveries to customers.

Prevention Costs

FMC is organized in projects, and it is during these projects the design of new products is performed. When designing new products, the extra work carried out to ensure that they are according to specifications, easy to service and maintain while in use is considered as prevention costs, as mentioned in the theory as "design engineering".

In correspondence with a Supply Chain Manager in another FMC location, he stated that they sometimes use third party inspectors that have to be stationed at the supplier's site at all times to ensure that the quality of products are maintained. This is not a desired situation, but is done in those cases where supplier performance is not up to the required

standard, and FMC do not have any other option due to the single source situation of these suppliers.

Third party inspections are also a cost driver that fits under the cost of quality element and according to the Supply Chain Manager in FMC should be included in a TCO model. Some suppliers require more attention than others, whether it is due to poor OTD performance or due to quality issues. In FMC third party inspections are sometimes used when a supplier is not delivering the expected product quality. If this is a persistent problem and FMC have no choice to switch to another supplier because of a single source situation, a third party inspector may have to be located at the supplier's site at all times. This is a factor that is relatively easy to estimate and can contribute to large extra expenses on particular suppliers. For that reason it will be suggested included in a potential TCO model. This data should be found in the SAP system.

Appraisal Costs

This is where inspection of deliveries and testing of end-products are performed. To calculate the inspection costs is a fairly straightforward task, which mainly includes the man hours the inspection requires. As a part of finishing a product, FMC performs together with their customer a final test of it.

External Failure Costs

In the business FMC represents, defects on products that are discovered after it is delivered to customers could create huge consequences, both in loss of reputation and financially. It is, according to FMC representatives, extremely important that the product that is delivered to customers is of the highest quality possible. It is therefore probable that high appraisal costs are acceptable in FMC, if it leads to low (or non-existing) external failure costs.

Other Quality Related Costs

Opportunity costs are also a factor to consider when dealing with man-hour driven costs. The time spent on for example rework, which is considered a non-value adding activity, could have been spent on a productive value adding activity if the quality of the product had been up to standard. Though, in the literature, the opportunity cost is regarded as a cost that is difficult to measure, and is often omitted in cost analyses because of its complexity. For instance would the rework in the latter example be considered an opportunity cost if the employee, because of the rework, did something that differed from the normal job routine. But if the person is hired to handle defects and this is the job that he is expected to perform, it would not be regarded as an opportunity cost. In FMC there are several persons involved when a QN occurs, some have it in their job description as part of the daily work, and some not. Due to this, opportunity cost is very challenging to calculate in FMC today and will not be reviewed any further by this thesis.

If concrete data and information related to cost of quality is lacking, it can also be calculated on a more general basis. In an earlier project at FMC, three students from Høgskolen i Buskerud (HIBU) (Grepperud, Kløvstad & Villarroel, 2007) found that the average cost of poor quality from suppliers are approximately 6000 US-$ per QN. This is a relatively humbly estimate when they also say that the cost of poor quality may constitute 15 – 40 % of the business costs. Though, the use of estimations of fixed costs shown above is conflicting with idea of TCO. In this thesis, the purpose of TCO is first to visualize the total cost of a supplier. Secondary and maybe more important is to evaluate, make decisions and compare suppliers based on the data that makes up the TCO. If a cost driver in the TCO model is converted from variable to fixed, there must be a clear reason for including it because it will not provide the true cost of that cost element, only an estimation that will vary on the number of QNs. If a cost is just assumed and the same cost is dedicated to all the QNs, the only difference would be the number of QNs. Evaluations based on number of QNs are already used by FMC based on Key Performance Indicators (KPI).

6.4.3.2 On Time Delivery (OTD)

As for cost of quality, there are several cost drivers that contribute to estimate the total cost of delivery performance of a supplier. The traditional way of thinking OTD - performance of a supplier has been to measure late deliveries. During this thesis it has been acknowledged that OTD - performance not only is a question of delivering a product on time, but also that there are huge variations in costs related to getting the products on time. This will be illustrated in the example below.

Example: A company has two suppliers within the same commodity. They both deliver on time, every time, but one of them has higher OTD - costs. The reason is that the first supplier delivers on time without any exertion by the customer, while the second supplier requires a lot of expediting and customer-supplier relation management to deliver on time.

On Time Delivery (OTD) is rated as the cost driver with the second biggest impact on the TCO result by the respondents of the survey. This is also in accordance with the hypothesis, the existing FMC SPI models (Appendix A) and theory on the subject. Therefore the relevance of this cost driver is considered as high.

Unused capacity/bottlenecks

Deviation from OTD is in the theory described as cost of time. Unused capacity and bottlenecks can occur. It is challenging to correctly estimate the cost of delivery delays in FMC. This is because there is no consistency in the data that tells when the product is required. For one instance the set date for a required delivery is months ahead when the part is needed in production, in other cases the required delivery date is the date when the product is really needed. For delivery delays to be correctly calculated, the input in SAP must be correct, consistent and standardized. In the survey the OTD element came out as the second most important cost to estimate beyond price, but no one of the respondents or anyone else that has been contacted could give any concrete information on how to estimate the cost of delivery delays. As far as this research has recognized, there has not

been officially made any effort to calculate the actual costs of delivery delays in FMC. An alternative approach when lacking data is, according to the theory, to develop data based assumptions. Two FMC locations have already developed a SPI- based, or according to the theory, a value- based approach to estimate quality and OTD. The delivery performance is measured in certain monthly intervals. And the supplier gets a score based on the performance. For example if the delivery performance is 80 % for a three month period, the score is 90. Based on the score an index is calculated that is multiplied with the spend with the supplier in that period. This will provide an assumed cost of delay. It is hard to estimate the accuracy of this cost, but if it is done in a consistent way, the period to period performance trend of the supplier will become evident. The result will also provide information for evaluating suppliers against each other.

The unused capacity that a delay causes in the production is, according to the theory on the subject one of the main cost drivers to consider when estimating the cost of delays. To perform this in a correct way, Value Stream Mapping could be performed. Value Stream Mapping also reveals any bottleneck that the delay creates. In addition to the mentioned cost drivers, it will also include change in schedule, ad-hoc planning, extra meetings. Such activities are case dependent, and hard to standardize. To track each activity related to delay in production would need extreme discipline and commitment from those taking part in this process.

Inventory related costs

There are costs related to early deliveries, too. These costs can be significant dependent on the cost of the product. A quick search in FMC's SAP system reveals that products can be delivered more than 100 days earlier than scheduled. This can generate a considerable amount of cost knowing that the inventory holding rate is 15,5 % p.a. of the direct spend. This information was provided by a Commodity Manager and is divided in

to four elements: 10,5 % cost of capital, 1,5 % tax/insurance, 2,0 % storage and warehousing, 1,5 % obsolescence. Using this information the cost of early deliveries can be calculated in a fairly precise way. The suggestion from this thesis is to include the cost of holding because it is fairly easy to measure, even though there are mixed signals from different FMC employees if it is relevant to include, or not. It is anyway likely that a TCO model needs adjustments during the first period of the implementation and adoption. During this period the cost drivers that are of minor importance should be excluded from the model.

Expediting

Expediting is from several FMC employees stated to be a considerable activity and is ranked by the respondents of the survey in the middle part of the critical cost driver scale. Because of this it should be considered in a TCO model. The main purpose of expediting is to prevent deliveries to be late, in other words increase the OTD of a supplier. Expediting is performed in different ways, depending on which location is considered. Expediting may be performed by purchasers, or specific personnel. To estimate the cost of expediters should be a rather effortless task, assumed the activity based costing method is used.

In the current situation in FMC, expediting and supplier relation work is a cost that is challenging to estimate. These costs are mainly driven by man-hours and travels to the supplier. Because all FMC employees register their man-hours and travels either on a project or on their department, these costs can not directly be allocated to a supplier. So for correctly estimating the costs of expediting and supplier relation management in a beneficial way there is need for allocating these costs to suppliers. As for now this is not possible in a cost and time beneficial way according to a Senior Project Analyst in FMC. To get fairly accurate data on expediting and supplier relation work it has to be gathered and implemented to a TCO model manually. This is likely to be a very time consuming process and are therefore by now not recommended by this thesis.

Unnecessary Transportation costs

Another factor that is not seen in traditional OTD-analysis is the cost of extraordinary or unnecessary transportation. If the forecast tells that the ordered product is expected to be late, it will in some cases be necessary to consider a faster method of shipping. This can be expensive and is adequate to include in a TCO model in those cases FMC is paying the extra costs. After speaking with one of the Commodity Managers it was acknowledged that these expenses are often covered by the supplier, but require a great deal of expediting and negotiation from FMC.

The unnecessary transportation costs are often very expensive, as they often occur when there is a delay in production, low quality of products or otherwise need for extra shipment. The cost of this transportation, and the administration linked to it should be included as an element in the TCO model. This is mainly due to the easy calculation of such a concrete cost, and the impact it could have. All in all, including the unnecessary transportation costs in TCO provides a good Cost/Benefit ratio. The cost of extraordinary transportation can be found in the SAP system and is probably fairly accurate, but it is by now not linked directly to a supplier.

6.4.3.3 Transportation costs

Costs related to transportation were ranked in the middle part of the scale by the respondents to the survey. It may not be a major cost compared to quality and OTD costs, but it is a cost that is available in the system today and it is by this thesis regarded cost beneficial to implement into the model. Transportation costs can vary a fair amount within a commodity. Example: A Norwegian company has dual-sourcing for a specific commodity. One of the suppliers is located in Sweden, the other supplier is located in South-Africa. When performing a TCO analysis it becomes clear that transportation costs can vary considerably. The transportation costs and to a certain degree the responsiveness of the South-African supplier is likely to be high in comparison to the Swedish supplier.

Even though the South-African supplier prices his product a considerable amount lower than the closer Swedish supplier, and the initial TCO analysis provides an equal result for both suppliers, the potential cost of the South-African supplier is much higher. If there should emerge a quality issue and the parts received have to be returned to the supplier for repairs, or due to some delay, the parts have to be shipped by extraordinary transportation, the South-African supplier would generate much higher potential costs than the Swedish supplier. The point is that if the transportation costs are high, the potential costs are much higher. Due to the availability of the data in FMC's SAP system, and the potential costs that may come along with transportation it should be included in the TCO model. Insurance is a cost that also should be included as a transportation element because it is a contributing factor to these costs.

6.4.3.4 Supplier development costs

These costs are in some cases significant, and in other cases non-existent. These costs tend to increase when dealing with new suppliers, but in some cases these costs are present even when suppliers have been used for several years. The contribution these costs make are also dependent on the actual spend on the supplier. If the spend is low, and a lot of supplier development is required, the proportional costs will be high. As an example an informal estimation of the supplier development costs was conducted at FMC by a Supplier Development Engineer. This case only consisted of one supplier, but in return the Supplier Development Engineer knows this supplier very well. In 2007 the spend on this supplier was about 14 M US-$ and in pursuant to the estimation, three FMC employees worked about 2500 hours at a cost of estimated 100 US-$ per hour. This contributes to about 250 000 US-$ and about 1,8 % of the spend. These are just the costs of time spent by three employees at this supplier. The travels, accommodation and extra costs are not included as they should be. As a percentage of spend this is may be not an alarming number, but it is a considerable amount in dollars and should be included in a TCO model. In the current situation at FMC it is not possible in a cost efficient way to get

hold of data that relates time spent to suppliers. This must for now be done manually for example by educated guesses.

6.4.3.5 Summary

This part will compare which of the mentioned costs/cost drivers that have resemblance to relevant theory on the subject.

Both the example regarding the above mentioned supplier and the example regarding third party inspection costs, have resemblance with the transaction cost mentioned in the theory part of the thesis. This is a good example on how lack of trust in a supplier increases the transaction costs, and therefore also the TCO. Another example on increasing transaction costs are noticed when the earlier mentioned strategic supplier communicates with other than one special person in FMC. This fits the category of uneven power, whereas the supplier believes to hold more power than FMC in that specific case.

The need for heavy expediting in FMC is also contributing to increasing the transaction costs. This is where cost/benefit analysis should be utilized, and expediting should be conducted until it is no longer cost efficient (ALARP). When this is not cost efficient anymore must be considered in each case.

6.4.3.6 Suggestion to approaches for developing data when data is not currently available

As mentioned in Chapter 2 and Chapter 3 the data required for performing an adequate Total Cost of Ownership analysis is not always available in a company's systems. This is one of the main barriers for several companies in conducted case studies and for FMC. This can be because of the complexity of major costs as they can be based on several variables within and maybe outside the company. Another reason can be that the focus on cost allocation, such as ABC, is not present.

How have companies in similar situations as FMC proceeded when lacking data and information? As this is an important question to answer for this thesis and not much information on this was found in the literature, Lisa Ellram, the author of several papers, case studies and reports on TCO was contacted. She responded that in good companies a sensitivity analysis would be conducted with a low, expected and high estimate on the costs. Surprisingly, in many cases it proven that whether one estimated a high or a low cost, the result would not change meaningfully based on the hard to obtain data. In those cases where the result did change based on the hard to obtain data, the companies would have to make a decision. One option is to invest in trying to gather that data because it is crucial to the conclusion. Another option is to present the results with the incomplete data to the management and allow them to make the decision about what to do.

Example: Texas Instruments found them self in a similar situation as FMC Technologies. It was difficult to gather the cost data related to purchases. Much of the data was aggregated by the commodity group, so it was difficult to break down data by the individual supplier and item. Their approach for a solution to the problem was to form a team for the task. It took about two years to overcome the barriers with developing methods for cost allocation and required a lot of team work and consensus building. Texas Instruments came out with a result for cost allocation that was very similar to Activity-Based Costing and based on this they formed a TCO model. Their concept behind the model they developed was that activities generate costs (Ellram, 1994).

As the latter example shows, Texas Instruments decided to invest in trying to gather the hard to obtain data. Another company, Northern Telecom (NT), also found them self in the same situation as Texas Instruments. How could they provide good TCO data/information for the end users? The solution to overcome this barrier was to set up good ABC "drivers". As this was going to be a time consuming, complex process, they used student interns and cooperative education students to perform much of the technical work (Ellram, 1994).

None of the companies in the study performed by Ellram (1994) had ABC like systems already in place to provide usable data and information for a TCO model. All the companies had to address the same challenge that FMC now is facing; readily available relevant data. The examples above are chosen for the reason that their purposes of the TCO model are very similar to what FMC want to get out of a TCO model.

6.5 Obstacles for FMC to implement a TCO model

6.5.1 General

The findings in this chapter are a combination of results from brainstorming/discussion between the authors of this thesis and FMC employees, findings in FMC systems, and findings in the literature. The results are discussed, and relevance is considered.

In a case study performed by Ellram (1998), she presents a study where the biggest "challenges and barriers to TCO implementation" are listed. The data was gathered through interviews and questionnaires and 11 different firms that had implemented TCO were involved. The results from this study are evaluated and used in this chapter. In this study, both the barriers of implementation and the barriers that occur during the use of TCO are considered.

As mentioned in the theory part, there are barriers to overcome when implementing a TCO model in a firm. As this thesis carried on, the recognition of several elements from the theory became evident, and this will be elaborated further in this chapter.

6.5.2 Discussion of barriers for FMC to implement TCO

As Ellram (1993) states "purchasing does not fully implement the TCO approach because of lack of top management attention". Even though no evidence of this was found (no investigation was performed), indications of this came up when interviewing FMC

employees. The Key Performance Indicators (KPI) found on the Intranet show another indication which emphasizes this. They do not mention TCO when evaluating suppliers. As of now, there is no one in charge or responsible of designing and implementing a global TCO model at FMC.

TCO could require a cultural change (Ellram, 1995). Ellram states that a firm should consider more than just the purchase price when evaluating suppliers. To elaborate this even further, the culture in FMC related to suppliers is evaluated. The following data is gathered during interviews and informal conversations, and it is therefore to be considered more of a discussion of improvements in FMC, and more thorough investigations are necessary to get to a conclusion.

To make sure that FMC fully makes use of the knowledge they obtain when interacting with suppliers, they should have a method of quantifying, registration and sharing the essential data in SAP. SAP is a globally used system, which helps different locations share their knowledge. Instead of each person keeping supplier related data in their own way, a formalized system must be provided. To formalize the TCO process will prevent subjective supplier rating, as it does when "gut-feeling" or specific personnel is involved in the activity. As a Commodity Manager stated "there is a significant difference in how the supplier behaves, when I am a part of the meeting, and when I'm not". This refers to the fact that specific FMC people have a considerable amount of knowledge of this supplier, and know most of their history. A TCO model could help FMC to have leverage no matter which purchase personnel performed the negotiation. This will also ensure that all suppliers are rated similarly, and correct supplier selection is performed.

The main obstacle (when it comes to TCO implementation) for FMC as of today, is the lack of an activity-based costing (ABC) accounting system. Ellram (1993) states that

"information on all costs must exist". It is noticeable to reflect on Ellram's usage of words, as she says "**must**", and not should. This is considered to be the foundation of any TCO model, and could actually be considered as a TCO model it self, as it allocates the cost at the right place. As of now for example, the costs of purchase personnel for example is put in one pool and considered as indirect costs and therefore not traced back to any supplier. To implement ABC would require great effort for FMC, but it is by no means impossible, as proven by ExxonMobile and General Motors which have implemented ABC. (Horngren, Datar & Foster, 2005)

Ellram (1993) considers data availability to be a huge barrier. This seems to be the case in FMC as well. During the investigation period of this thesis, there was not scheduled enough time to investigate/quantify cost drivers, as it turned out to be a time consuming and challenging work. There appears to be some resistance to implement activity-based costing, and there is no uniform and standardized method for registration of supplier related data. There seems to be an understanding of that there is more than enough data in SAP to produce decent analyses. The problem seems to be that it is difficult to extract and process them. This is not proven to be true, as ABC is not implemented, and costs are not allocated to suppliers. This could indicate a lack of understanding of what Sap's possibilities are; and how to store different data in the system.

If time was set to estimate the true cost of activities related to a specific purchase, including delay of deliveries, quality problems, expediting and so on, FMC would not be able to use this result in a long run. This is because of the changes in production, and the relatively low volume of products FMC receives from their suppliers. If FMC i.e. receives 100 units of a product, it would provide a poor Cost/Benefit result to perform a thorough analysis on a specific product.

The reason is that in this case, that work would have to be performed manually by interviewing personnel, estimate travel expenses, calculating costs of quality and delays and so on. This type of evaluation would have to be performed each time a TCO analysis

was required, which would lead to subjective measurements and estimations each time. To have a standard TCO model, without the use of Activity-Based Costing, which has a standard method of allocating costs, is difficult. FMC has a huge challenge here.

The purchase strategy should be the foundation of TCO/SPRS (Ferrin & Plank, 2002). None of the survey respondents said there was any "defined or written" sourcing strategy in their location. This could be seen in accordance with the earlier mentioned "lack of top management attention", as both elements include involvement from senior management due to the global implementation of both TCO and a purchase strategy.

During the brainstorming process between the writers of this thesis and a Supplier Development Engineer at FMC, one of the elements that came up was "lack of interest among FMC employees to work with TCO". This could be seen in correlation with the earlier mentioned lack of purchase strategy and senior management interest, as well as the relatively few survey feedbacks that were received from the different locations.

As a further result of this, it is necessary to evaluate the validity of the considered cost drivers, except OTD and Quality as there seems to be mutual agreement.

Ellram (1998, p 14) also states the following as a potential barrier to TCO implementation "Use (of a TCO model) is voluntary in each division: need to sell benefits of use to internal users throughout organization", and further "How to get buyers away from "price" mentality".

This seems to be the case in FMC. The purchase personnel in FMC do not have a standard system that **must** be used. As long as there is no incentive system, or other method which "forces" buyers to change their way of behaving, there is no reason to expect them doing so.

"TCO is not used uniformly in all divisions, even when same suppliers are used by different divisions" (Ellram, 1998, p 14). As FMC has not implemented any kind of TCO

model yet, this cannot be investigated. But there are indications that this will be the case. As of now, FMC lack mostly use of global systems, evaluation models and routines when it comes to supplier evaluation. There is no indication for that there will be a unitary use of systems when a TCO model would be implemented.

The complexity of a TCO model is mentioned as a potential barrier. This is mentioned both from the literature (Ellram, 1998) and from FMC. As a FMC employee stated "complex models are not used in FMC". This must be considered together with the fact that there are obviously no consequences if systems are not used, as this further enhances to not use complex models.

Ellram (1998) further mentions "users get too caught up in details, forget cost/benefit". This is also something that can not be considered before any model actually is implemented at FMC. It is though worth noticing, as all participants from Ellram's field study (1998) state that this is the biggest barrier to overcome after the TCO model is implemented. Chapter 2.2.5 on CBA and ALARP should be considered here.

"TCO is time-consuming to develop: big initial time investment" Ellram (1998) is reported from all participants in that study to be a barrier. It is likely to believe that this would be the case in FMC as well, due to the global nature and wide span of FMC.

"Need to save money" Ellram (1994) states this as a denominator in firms which have successfully implemented TCO. FMC has not had that focus on cost-reducing activities as the automotive or electronic industries. This could change within a few years, due to new competition in the market.

6.6 Overcoming barriers

In the same study where Ellram (1998) describes the challenges and barriers to TCO implementation, she also describes some of the solutions of how to overcome these barriers. As FMC has not yet implemented a TCO model, this section describes potential

future work. The recommendations listed are a result of what is stated in the literature, and also what – due to findings in FMC – the authors of this thesis believe will be relevant in this case.

6.6.1 Discussion of how to overcome barriers

To prevent FMC from using different TCO models in each location, the immediate implementation of standard global routines would prepare employees to use any global system. These systems must be linked to SAP, to be able to share the different results. This would also be helpful for FMC as there is a high employee turnover.

To prevent FMC employees from using the TCO model in different subjective ways, common training of all relevant personnel should be conducted. Training classes/education which surmounts the user's fear, provides guidance, teaches the proper scope of TCO applications and how TCO supports strategic management decisions is according to Ellram's (1998) study the most helpful measure in an organization that recently has implemented TCO. This will further help people understand that the purpose of TCO is not to pinpoint blame towards one department or an individual, but to use TCO as a tool to help FMC as a global firm.

"Have teams/users build TCO models or have input into TCO analysis". During the earlier mentioned brainstorming it came up that there could be resistance to change in FMC. Including users in the process of creating the model would create a smaller barrier to overcome, as the model would be known to the users as they have influenced it in the creation process.

"How the purchasing process is viewed by the organization". This is one of the elements where FMC should have an advantage, as purchasing is regarded as a core activity according to FMC's business processes on the intranet. Despite of this, the initiative of implementing TCO in the organisation did not origin from senior management, but from sourcing/purchasing departments.

"Implement TCO in the whole organization". As a result of the brainstorming, the issue came up that FMC is organized in projects, and the impact on TCO starts here. Ellram (1998) stresses that TCO is a philosophy and that it should be implemented in the entire organization. This seems to be relevant and important to FMC, as their core value (manufacturing of subsea equipment) is created in those projects. If the TCO culture is spread into both the projects and the rest of FMC, the result should be visible due to standardisation of products and routines. Written standards and routines in the organization prevent new employees (one location hired about 500 in 2008) from doing the same mistakes as their predecessors did (As mentioned earlier).

6.6.2 Summary

When implementing TCO, ABC or any other global system in FMC, it becomes more challenging and difficult without a system that ensures the introduction of new routines in an effective manner- and in all FMC locations at the same time. Ellram (1998) describes a firm which assured that when the TCO model was introduced, it was well tested; it worked as intended and was introduced without any more changes. This seems like a method FMC would embrace, as it is coherent with the "do it right first time" philosophy at FMC. The way the mentioned firm organized the implementation was to introduce in one project a pilot TCO model, which could be changed, adapted and evaluated during the initial phase. Other firms used other approaches where they introduced an initial model simultaneously in the firm, and then each user of the model could have impact on the final model. The latter approach would theoretically be a good one, but demands discipline, systematic work and involvement from the users, as well as extensive communication between all involved parties. As discussed earlier, a formalized system, which would be the foundation of such an implementation method seems to lack at FMC. It is therefore likely to presume it would be challenging to conduct.

6.7 Evaluation of existing TCO/SPRS models in FMC locations

This section will take a look at the already existing TCO/SPRS models of the different FMC locations. They will be evaluated according to the theory described in the earlier chapters of this thesis, and be used as a foundation if a new model is developed. These models also provide an impression of what FMC considers as their main cost drivers, and what they believe should be the main area of focus.

6.7.1 Overall view of the existing TCO models

None of the models describes their foundation. As described earlier, the SPRS or TCO should be developed as a result and continuation of the overall procurement strategy/vision. FMC's global quality vision is:

"FMC Technologies Inc., in partnership with our suppliers, is dedicated to providing systems, products and services which meet FMC and our customer's requirements of safety, quality, reliability and delivery. All employees are committed to the continual improvement of the processes of our quality management systems." (FMC Intranet)

Further, it is stated on the Intranet business goals, which among others are:

"…deliver quality products and services over 98% OTD…"

This is a statement which (according to the theory) should be transferred through the existing TCO model. However, this is a vague statement to be used in a TCO model, and does not provide much assistance when designing such a model. As the respondents of the survey stated, their locations do not have, as of now, any written or defined sourcing strategy. Due to this, experience with purchasing, general theory and subjective understanding must have been the foundation when creating the following TCO model.

6.7.2 SPI- method used by two FMC locations

This model was designed by a Strategic Sourcing Manager. It bears a resemblance with the model described in the literature by Carr & Ittner (1992) and the value- based TCO approach by Ellram (1995). According to the creator, it is not totally "baked" yet, but the outlines are pretty clear.

The main elements in this model rate suppliers according to OTD and Quality, using a formula to create a Supplier Performance Index (SPI). This index is multiplied with the purchase price to indicate the "true" cost of the supplier. The SPI can also be used independently of the purchase price. This is a method which is accepted by the theory.

It considers the main cost drivers (Quality and OTD), but neglects the other underlying causes (Why is it delayed? Why is the quality low?), and has therefore some weaknesses.

The measurements (Quality and OTD) are in accordance with the hypothesis, and according to the survey they are considered as the two most vital cost drivers.

If managers wish to change the focus towards suppliers, it is easy to do so.

All in all, this model could provide the best result possible, without the use of ABC. It provides a great Cost/Benefit ratio, as well as it is rather simple to use.

6.7.3 TCO/LCC – Developed as part of strategic sourcing training

This model (Appendix B) was created during strategic sourcing training and is "designed to estimate all direct and indirect costs associated with the purchase of a good or service."

This model is (as far as the authors are aware) not in use in any FMC location. Perhaps one of the reasons is the complexity of the model. It has the possibility for about 50 inputs from the user, even though it is not necessary to include all of these cost drivers in the model. The amount of inputs can be chosen by the user. This model is by this thesis

only regarded as a framework or a suggestion for how a TCO could look like. This is because the model does not yet have any linkage to FMC systems and there is no documentation of how to obtain data for each cost driver in the model. As far as this thesis has recognized, the data gathering and linkage to other systems is the challenge of a TCO implementation.

One of the requirements from FMC was that the model should be simple to use, or it would not be used at all due to complex work such activity requires.

This model estimates the future costs, therefore it could also be considered as a life cycle cost tool.

The intention with this thesis was to create a tool which could evaluate the true costs of interacting with suppliers. To get this, one must use historical costs.

6.7.4 Summary of existing tools

The SPI model described is in use in two FMC locations. It is a solid tool, which delivers a proper result. Why it is not used globally? Why is there an existing tool, which is ready to use, simple and very cost efficient, but not used?

As earlier mentioned, there is indication of a lack of global routines in FMC. This could even support this statement. The question why it is not distributed globally is unanswered in this thesis.

Similar questions could be asked regarding the second tool. Why engage a consulting firm, when there is no plan of using the result they provide? Why is the result not provided to other locations?

The indications the lack of using these models provides, could further be investigated.

7 Result

The findings of the empirical investigation and analysis of this master thesis show that there is a desire for a tool for rating suppliers in FMC Technologies, but lack of readily available data prevents this thesis from coming up with a "ready to use" TCO model. However, when 65 %– 70 % of the turnover is spent on the suppliers, the potential cost saving opportunity is huge. Reducing spend on suppliers by only 1 % will equal about 29 million US-$ dollars. This is calculated from the turnover of 4,6 billion US-$ found in the 2008 forth quarter report of FMC Technologies. This emphasizes that FMC should give their suppliers the required attention, by rating them on a broader basis than just the purchase price. In this chapter the TCO method will be reviewed for FMC, based on the findings during this thesis. Alternatives and suggestions to further work will also be presented.

It could be argued that FMC, which has expanded rapidly the last years (25 % increase in revenue from 2007 to 2008), are more focused on the customers than suppliers. The business goals indicate this. This seems like a considered approach. To capture new market shares, get a good reputation among customers, and continue expanding to new markets are all important aspects when it comes to management decision. Is it impossible to both have an offensive attitude towards sales/development and expansion (as FMC has today) and at the same focus on decreasing expenses? This is a complex question, which has not been paid much attention in this thesis. From our point of view, this can not be answered. It is still noticeable to consider the low amount of attention suppliers and Supply Chain Management has in FMC's strategy document.

FMC does as of now not have full control over the expenses that occur when products of low quality are received. Perhaps macro economical changes are what are needed for FMC to really focus on their expenditures on suppliers. As of now, very few costs are allocated to suppliers so that the true costs are not known. As of today, only few suppliers to FMC are given claims when deliveries of low quality are received. With further focus

on optimizing supplier relationships, claims (that are more correctly estimated) could be given to all suppliers with low quality deliveries.

7.1 Is TCO the best method for supplier performance rating in FMC?

The purpose of creating a TCO model in FMC is, as mentioned, to know the true cost of suppliers. This is a part of improving the overall business, and as a tool to use when dealing with suppliers.

As of today, to be able to estimate the TCO, a thorough work, which involves several people from different departments, and even different locations, would be required. To estimate the cost of a QN could involve purchase personnel, production personnel, project engineers, sales personnel as well as cost controllers/finance personnel. The cost of a QN could be high, or it could be irrelevant. Not all defects are registered in SAP, and the opportunity cost is difficult to assess. It is acknowledged in FMC that delays and quality issues generate unnecessary costs; the challenge is to determine the amount of costs they generate. This due to the different impact each defect generates, and even the same defect on different shipments could have different impact on the production, depending on other activities in the project in production.

One task of this thesis was to perform an in-depth case analysis of a strategic supplier. This supplier delivers a low-volume product, and delivers to most of FMC's projects. If a Process Flow Chart would have been sketched up (as a tool to help estimating the TCO), it is expected that a proper result could have been provided. In cooperation with the right personnel, the amount of man-hours, the cost of material, and the administrative costs and so on could have been estimated within an acceptable deviation to estimate the total cost of i.e. a QN.

To ensure that FMC makes use of this type of analysis, there must be an opportunity to make organizational changes as a result of the findings. The changes could be at the

supplier, or the changes could be internally in FMC. This is where the support of senior management is important. To be able to improve routines, as a way of lowering the TCO, may need the support of senior management.

The challenge thereafter lays in the amount of the carry-over effect one single TCO analysis has on the next QN, next delay or other irregularity either from the same supplier or another one. It could have a lot, or it could have very little similarities with other QNs. This challenge will occur as long as there is no formalized system of gathering, storing and collecting the relevant data that is related to TCO activities. To be able to perform cost-effective analyses in the future, changes in the cost allocating method must be performed.

It is likely to believe that FMC personnel would not have time to create Process Flow Charts to capture supplier QNs, delays, expediting, and transportation cost, each time a TCO was required. The intention must be to lower the threshold of performing an analysis.

Is TCO old fashioned?

Is evaluating suppliers using TCO old fashioned? To just focus on financial measurements is considered to be old fashioned by some authors (Kapland & Norton, 1996). It can be argued that a TCO model can measure whatever it is designed to measure, and it can. The challenge would then be to determine how to quantify the different subjective measures into unitary terms, as this is a very comprehensive task.

The challenge would even increase considering that FMC is an innovative firm, which competitive advantage is to create pioneer products, but only measure their suppliers on cost efficiency. This is, according to the theory a contradiction and is therefore unfortunate (Chopra & Meindl 2007). To encourage innovation and responsiveness at suppliers, TCO measurements alone will not fully embrace this.

As FMC is an Engineering To Order (ETO) firm, the projects vary in nature and shape. FMC are dependent on suppliers who can follow their path of innovation, responsiveness and willingness to adapt to new markets. Does TCO tell FMC which suppliers they should continue working with? Not necessarily, and not for all

How would the future development of a supplier be evaluated in a TCO model? It can't, nor should it. In the case of FMC, a TCO model would contribute to that part of supplier ratings which focuses on the financial measurements. The financial measurements provide an indication of the historic aspects of the supplier, and could be considered as a short term measurement. Considering future aspects, such as investment in R&D is considered more of a long term measurement.

All in all, a TCO model provides important aspects for supplier evaluation. It puts focus on OTD and quality, both being significant cost drivers that tell about the history of the supplier. The backside is that it does not provide any information about the future, it is hard to estimate responsiveness of the supplier or other "hard-to quantify" important aspects. Has the supplier implemented any changes lately, which will improve the products they deliver? Has the supplier invested in any R&D activities lately, which will provide better, cheaper or more innovative products in the future? If these elements were to be quantified and included in the TCO model, it is likely that the threshold of using this model would be even higher. In addition to this, just to provide information without quantifying it would, in the authors' opinion, provide just as good result.

Future studies on this subject should focus on a broader supplier evaluation view, where the TCO element should be one of several elements to be included. Other elements which focus on long term, and non financial measurements should be included, such as those included in the balanced scorecard.

7.2 Supply base Total Cost of Ownership as an alternative

This idea was proposed by the sponsor of this master thesis when it became clear that it would be unlikely for this thesis to come out with an "out of the box" working TCO model. It was asked to investigate the supply base TCO further as an alternative to the traditional TCO and in light of the findings that already had been provided. This thesis will not come up with a "ready to use" supply base TCO model due to limited time, but point out relevant factors to include, and advantages and disadvantages for this kind of model. It is also expected that it is easier to get access to relevant data with this form of model, as the required costs are affected on a higher level.

The term supply base means all suppliers that are linked to one FMC location. In a global organization such as FMC, there are multiple locations around the world that perform the daily operations. These locations operate highly individual when is comes to sourcing and managing their suppliers. The reason for a supply base TCO is to capture all costs related to all suppliers of a location and allocate these costs to activities such as quality, OTD, transportation, cost of expediting and other costs that may be relevant for the specific organization. The results provided by a supply base TCO model can be used for comparing the supply base of one location against another location or used for analyzing trends within one supply base. This thesis has not found any evidence in the literature for this sort of TCO approach, but the idea has a foundation in high level activity-based costing analysis, where the costs not are allocated directly to a supplier or a product, but in this case, to several suppliers. As mentioned in chapter 2.1.1, this thesis, based on the findings in the literature, has defined TCO as: *"All **relevant** costs associated with the acquisition and use of an item that can be related **to a specific** supplier".* As there are no indications in the literature that a supply base TCO model exists, the definition will not change. However, it is acknowledged that a supply base TCO model may be helpful in developing and understanding supplier related matters.

In an informal conversation via e-mail with Lisa Ellram, she mentioned that a company named Parker Hannifin had developed a supply base TCO model, but she could not provide any written documentation on the subject. She emphasized that the foundation for this model is to utilize an activity-based cost management system internally.

By comparing supply bases for different locations on a high level will indicate which location is performing better. This information by it-self is maybe not useable for others than analyzing trends, but what is more important are the underlying causes for why one supply base performs better then the others. The activities that make up the total cost of a supply base will consist of several cost drivers, as for the "traditional" TCO model. The same rules apply for this model when choosing cost drivers to include. 20% of the activities cause 80% of the costs. The same drivers that apply for "traditional" TCO models will apply for supply base TCO models. For FMC this is likely to include cost of quality, OTD, expediting, supplier relations/development and transportation in this model.

If, for instance, a location shows a much better result in a supply base TCO analysis it would be interesting to know what the underlying causes are. By looking at the cost drivers it may appear that the costs of expediting are at a considerable lower level than the other supply bases. This will provide a basis for investigating this deeper. Until this point the decision making information has been based on quantitative data found in the system. The way forward may be to gather qualitative information on why this location handles the expediting cost of their suppliers better. This investigation may come up with a result that shows that this location has a well organized purchasing and expediting practice which leads to less unnecessary communication and relation with suppliers. Or the product specifications and documentation are better planned and carried out before they are sent to the suppliers. From this, FMC can get a learning process, which may eventually lead to standardization of "best practices" throughout the organization.

If a supply base TCO analysis indicates that there are huge variances in the cost of quality or OTD, the next step would likely be to try to find the underlying reasons for this. Is it the entire supply base that overall performs better or are there some exceptional good suppliers in the supply base that perform so well that it becomes visible in the result? In cases like this, a simple value-based TCO approach like the existing SPI method that is described in chapter 6.7, is likely to provide a reliable result on which suppliers perform better than the rest. When these suppliers are isolated it may be interesting to investigate further the reason why they are performing better on the specific activities. From this FMC can learn what factors contribute to the good results. This can be the case when the supplier has excellent process control or it can be some actions that FMC does, but may not be aware of them.

Supply base TCO would primarily be an initial tool where the supply bases of all locations are compared and evaluated. By looking for obvious variances in the result one can have a motive for investigating this further to relate the better or worse performance to a cause. By decomposing the result bit by bit the underlying cause may be identified and actions can be made based on the findings.

It has to be emphasized that this discussion is based on the researcher's thoughts and ideas based what is found in this thesis. It can to a certain degree be called explorative research where the reliability and validity of the discussion has to be investigated further. If FMC finds the supply base TCO model interesting, this thesis would suggest this subject as an alternative to later work on supplier evaluation tools.

7.3 Conclusion

The Total Cost of Ownership concept as described in the literature and the conducted case studies of TCO "success stories" are at first glance appealing and seems to be an effective tool for controlling and evaluating suppliers. This thesis recognizes the described benefits with TCO implementation and acknowledges that they can exceed the

barriers if the process of developing, implementing and adopting the TCO "philosophy" has broad support in the adopting organization. The major key for success is top management support and a strong desire for reducing costs, and readily available data. But, is TCO the best alternative for supplier evaluation in all cases and within all industries? As this master thesis carried on, the benefits and barriers of this specific case became more and more evident. The process of developing a system that in a cost beneficial way can use a TCO concept is going to be time consuming. There is even a risk that an ongoing project may be terminated mid way and if a TCO model was to be completed and ready for use, and there is no guaranty that it is going to be adopted.

As of today, FMC has just developed and to a certain degree adopted a SPI-based supplier evaluation tool. The development of this tool was initiated (according to our knowledge) at about the same time as this master thesis started, and has been developed simultaneously to this project. As far as this thesis recognizes, this tool is not accurate to the degree that one would like to see in a TCO model, but it will serve as a tool to assist in decision making processes such as rationalizing the supplier base and as an indicator for which supplier to choose based on price, quality and OTD performance.

This thesis started with the goal of developing and to a certain degree implementing a TCO model based on information and data gathered from key personnel in FMC, the SAP system and other relevant sources. Due to the findings during this thesis it was acknowledged that to fully implement a TCO concept would require a considerable amount of time and restructuring the systems used by FMC today. Therefore the aim of the thesis changed from developing a TCO model, to an investigation that was to answer "if TCO would be an appropriate tool for evaluation of FMC Technologies' suppliers".

As the discussion in chapter 2.2.7 indicates there are several barriers to implement an adequate TCO model. The most important related to FMC are that data at this point is not readily available and it would require a considerable amount of work to make these data available. This would include implementation of Activity-based costing. Another point

worth mentioning is that it has been indicated in informal conversations that top management MAY be a bit reserved when it comes to initiating processes that involve risks such as not exactly knowing the outcome. These are arguments that also have been stated in the literature and case studies as major barriers to the concept.

The final conclusion to the research question is that a Total Cost of Ownership model that relates highly on precise accurate data is not an appropriate evaluation tool for FMC, as the situation is today.

In the next chapter the recommendations on the basis of the findings in this master thesis will be presented.

8 Recommendations

As of now FMC Technologies has no globally standardized methods for evaluating their suppliers. This thesis has recognized the importance of supplier evaluation and the benefits it involves.

In the short term we would recommend:

- Make the global high-level sourcing strategy more visible.

Some locations already have started the process of developing a local strategy and by taking the best from each strategy would be a good contribution to an initial outcast for a global strategy. The advantage with having a well defined sourcing strategy is that it is a proactive way of securing that suppliers are selected on the predefined right terms. The most important element in a strategy is that it works as a control mechanism for transferring the thoughts and ideas from the strategic management positions to the operational positions. Further this global strategy can be adapted to fit various locations by designing location-specific goals.

- Globally adopt and further develop the SPI-based evaluation tool that just has been adopted by two FMC locations.

Additional factors such as transportation costs, inventory holding costs and third party inspection costs should be possible to include in this current SPI model. The disadvantages with this model are that the calculations of the total cost only are based on quality and OTD, and in addition the result is not reliable in terms that a conclusion or decision can be taken only on the basis of this model. The model is based on data from the SAP system, but is generated in a separate excel instance. Future development should focus on integrating the model in SAP. However, it is likely to serve as a good tool for initial evaluation of suppliers and help in cost saving decisions. As the model already is to a certain degree adopted in two locations, the process of implementing it at the other locations should not be too complex and could be done in a relatively short time frame. As for the cost of further development of this model and adopting it globally is by this thesis regarded low and manageable. And as mentioned earlier in chapter 7 the cost saving potential by just lowering the total supplier cost by 1 % would equal 29 million US-$.

- Further investigation of the supply base TCO model should be initiated to reveal possible ranges of use and how to generate data and which data should be adopted in such a model.

In a longer perspective we recommend:

- Developing and adopting a supplier evaluation tool that is tailored for the factors that are of most importance for FMC. These factors should be based on the most important elements of the global sourcing strategy.

The already mentioned factors quality and OTD should be included, but also factors that are more subjective such as innovative capabilities, responsiveness, and research and development. A typical and up to date choice would be a balanced scorecard type of

measurement. The disadvantage with a balanced scorecard model is the possibility for manipulative behaviour when rating suppliers. Therefore it is important that the persons that execute this evaluation have objective views of the suppliers that are measured. It is recommended that the personnel do not have direct operational contact with the suppliers, and should work on a strategic level. It is recommended by us to have students to investigate the possibilities of evaluation based on balanced scorecard or a similar model that not just focuses on the quantifiable costs. This is likely to result in a cost effective development process. The advantage with this kind of evaluation model is that it does not require a restructuring of the system. Therefore the development period should not take too long. The use of the model will though require some training.

If FMC decides to go further with the development of a TCO-based supplier evaluation tool we would recommend:

- Use the findings in this thesis as a basis for the future development of a TCO model. In Figure 8.1 the elements that this thesis regards as most important and according to the Pareto principle make up at least 80 % of the total costs.

Senior management and organizational support have been mentioned as important success factors. This thesis would recommend to:

- Initiate a case study of one or two suppliers where their TCO is calculated to get a "prove of concept". If the study proves to be a success the results can be presented to senior management and sourcing management to get their acknowledgement.

8.1 A conceptual TCO model

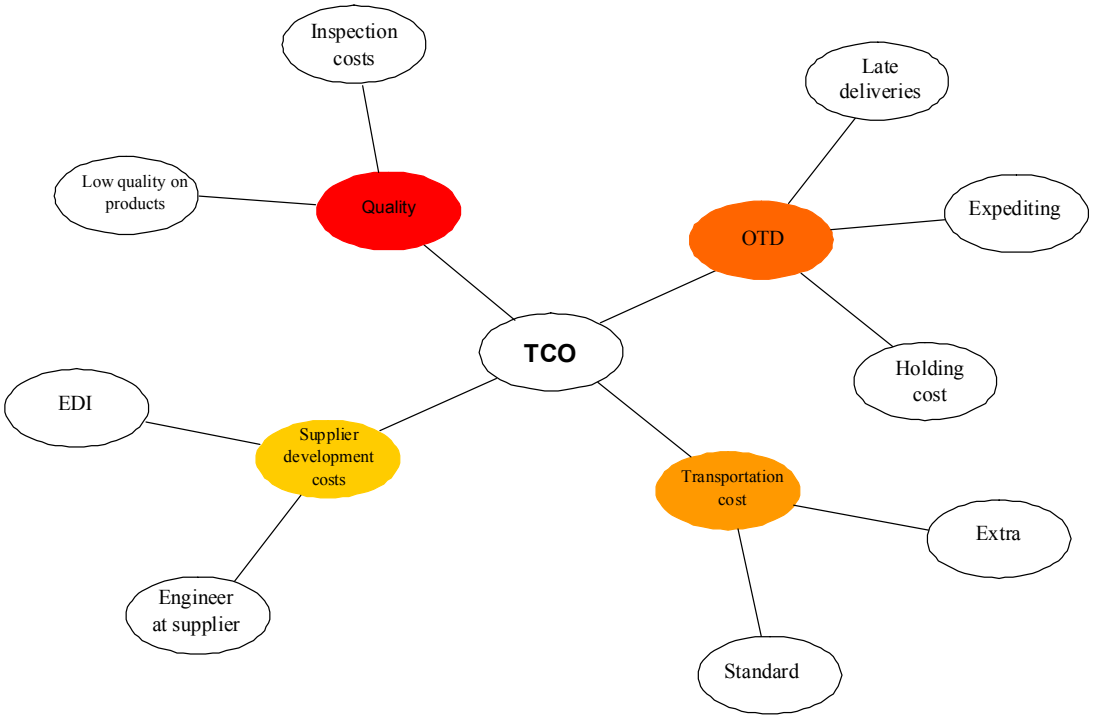


Figure 8-1 A conceptual TCO model

This figure shows the elements that, in our opinion, should be a part of a TCO model. The colour of the cost driver represents the impact it has on the result of the TCO; the more red it is, the higher impact it has on the result. All costs mentioned in this model (i.e. expediting or cost of implementing of EDI) are independent from each other. That means that there are several approaches to how to use the elements in this model.

1. Start with considering the easiest to obtain cost drivers, or
2. start with considering the most important/biggest cost drivers, or
3. start with considering several cost drivers at the same time

There are many other cost drivers that could be included in such a model, but this one includes in addition to the high impact ones, those that should be easier to obtain. This is

typically those costs that occur in a more direct manner. Those factors that are tough to quantify are left out, such as innovation capacity and responsiveness. The gathering of the different cost/cost drivers is described in earlier chapters, and so are also the activities to do when costs are missing.

This conceptual model could help providing an understanding of what actually increases the TCO, and if FMC decides to develop a TCO model, these cost drivers would likely contribute to 80% of the costs. Even if estimating these costs is not performed, a reminder of these costs, both to suppliers and FMC could contribute to lower TCO.

9 Quality of this research

A good research demands high reliability and internal and external validity. These criteria are explained in chapter 4.5 and are the foundation for evaluating the quality of this research. Here follows a discussion of the reliability and validity of this thesis.

Reliability

To ensure high reliability of the research means that the investigation can be repeated at a later date and provide the same result. This research is based on methodical triangulation and will therefore be affected by the personal opinion and interpretation of the researchers. By this, the results of this research are a basis for interpretation by others. Another researcher would maybe have concluded differently based on the gathered information and data. Therefore there are potential sources for errors in the researchers' conclusions and interpretations of the empirical investigation. What strengthens the reliability of this research is that there are two researchers working on it. The interviews, questionnaires and conversations are carried out by two persons and the results are discussed subsequently to the events.

Construct Validity

The empirical investigation of this thesis has been based on informal conversations with various key personnel at FMC Technologies and two questionnaires that were aimed at supply chain and supplier development personnel that may find a tool for evaluating suppliers useful. Although the responses on the questionnaires did not meet the expectations, the respondents that returned with an answer are personnel that have good knowledge of FMC, how FMC operates and have a foundation for answering the questionnaires. To ensure the construct validity of this research the proposal of cost drivers for a potential TCO model has been in accordance with what was responded in the questionnaires and with various inputs from several informal conversations with key personnel. The results have also been checked against externally conducted case studies of similar proportions. The construct validity is based on the latter regarded as satisfactory.

External Validity

The external validity of this research is challenging to estimate at this point. Because measuring external validity requires that results from several investigations are compared we can only assume an external validity based on what we have found. The information provided in this study is comparable to what was found in the literature and case studies on the subject. This thesis considers the connection between the answers provided in the questionnaires and the contributing theory and case studies as factors that help increasing the external validity. However, there is no guaranty that the responses to the questionnaires will have the same result in a similar case in another company. The opinion of other respondents in another case may be different. This is a complex subject that involves several case specific variables which leads this thesis to believe that the final conclusion and recommendation will vary among companies. Though, the

challenges met in this thesis and the answers of the surveys are to a certain degree possible to generalize according to the case studies that this thesis has reviewed.

10 Abbreviations

ABC – Activity-Based Costing

ALARP – As Low As Reasonable Possible

BSC – Balanced Scorecard

CBA – Cost/Benefit Analysis

COQ – Cost of Quality

EDI – Electronic Data Interchange

ERP - Enterprise Resource Planning

ETO – Engineer To Order

FKS – FMC Kongsberg Subsea

KPI – Key Performance Indicator

LCC – Life Cycle Cost

LCA – Life Cycle Assessment

MRP - Material Requirement Planning

OTD – On Time Delivery

PLC – Project Life Cycle

QA - Quality Assurance

QN – Quality Notification (SAP term for NCR - Non-Conformance Report)

R&D – Research and Development

SAP - Systems, Applications & Processes in Data Processing

SCA - Supply Chain Analysts

SDE – Supplier Development Engineer

SCM - Supply Chain Management

SPRS – Supplier Performance Rating System

SPI – Supplier Performance Index

TCO – Total Cost of Ownership

VSM – Value Stream Mapping

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FMC Intranet

12 Table of Figures

13 Appendix

13.1 Appendix A, SPI model, Method used by two FMC locations

FMC Technologies

Supplier Performance Program

Supplier Performance Index Calculation

Quality, OTD and Supplier Scores

February 2009

Summary

- Supplier Performance Index (SPI)
  - QN SPI
  - OTD SPI
  - SPI Calculation
- Supplier Score
  - Quality Score
  - OTD Score
  - Supplier Rank/Score

Supplier Performance Index (SPI)

- QN SPI
  - ZC, ZD(gr) and ZD(p)
  - QN Points
    - Calculation
    - Why?
  - OTD SPI
    - Definition
    - Calculation
  - SPI Calculation

QN SPI

- ZC, ZD(gr) and ZD(p)
  - ZC = 1 point
  - ZD(gr) = 5 points
  - ZD(p) = 10 points

Total in NOK (3 months period)	ZC	ZD (gr)	ZD (p)	QN pts	QN pts/$M	QN SPI
66 742 248	53	115	10	**178**	2,67	0,04
16 545 141	2	20	20	**42**	2,54	0,04
2 321 381	0	0	10	**10**	4,31	0,07
10 465 131	1	25	10	**36**	3,44	0,06
9 753 878	2	0	0	**2**	0,21	0,00
105 827 778						

- QN Points
  - If QN Pts/NOK 1M < 40, multiply QN Pts/NOK 1M times .606 then divided by 100
  - If QN Pts/NOK 1M > 40, take 66 and divided by 100 to give a score of .66
- Why?

  Houston team decided anything greater that 40 QN Pts/NOK 1M was really poor quality performance. It was decided a score of 66 = 40 QN pts/NOK 1M, this means each QN Pts/NOK 1M = .606

OTD SPI

- Definition
  - OTD % is made up of On Time and Early deliveries
- Calculation
  - 1 minus OTD% (in order to obtain % late) divided by 3

OTD% Not Late	OTD SPI
86%	0,05
75%	0,08
85%	0,05
97%	0,01
64%	0,12

SPI Calculation

- 1 + (QN SPI + OTD SPI)

QN pts/$M	QN SPI	OTD% Not Late	OTD SPI	SPI
2,67	0,04	86%	0,05	1,09
2,54	0,04	75%	0,08	1,13
4,31	0,07	85%	0,05	1,12
3,44	0,06	97%	0,01	1,07
0,21	0,00	64%	0,12	1,12

Supplier Score

- Quality Score
- OTD Score
- Supplier Rank/Score
  - Houston Methodology
  - Kongsberg Methodology

Quality Score

- If spend is less than NOK 50K than give 80. There is no enough spend to rank against other supplier with much higher spend.
- Otherwise,
  - < 6 = 100
  - 6 – 11 =95
  - 12 -20 = 80
  - 21 – 39 = 70
  - > 39 = 0

Total in NOK (3 months period)	QN pts/$M	Quality score
66 742 248	2,67	100
16 545 141	2,54	100
2 321 381	4,31	100
10 465 131	3,44	100
9 753 878	0,21	100
105 827 778		

OTD Score

- If OTD% = equals « N/A » than give 80
- > 95% = 100
- 90% - 95% = 95
- 80% - 89% = 90
- 70% - 79% = 85
- 60% - 69% = 80
- <60% = 0

OTD% Not Late	OTD SCORE
86%	90
75%	85
85%	90
97%	100
64%	80

Supplier Rank/Score

- Houston Methodology
  - (QN Score + OTD Score)/2= Supplier Performance Score
  - RANK SCORE
    - Green 95 – 100
    - Neutral 75 – 94
    - Yellow 50 – 74
    - Red 0 - 49

- Kongsberg Methodology
  - (QN Score x 2 + OTD Score)/3= Supplier Performance Score
  - RANK SCORE
    - Green 90 – 100
    - Neutral 80 – 89
    - Yellow 70 – 79
    - Red 0 - 69

13.2 Appendix B, TCO model developed during sourcing training

FMC Technologies

KEY:
FMC Inputs are in Yellow
Do Not Change Red Formulas

TCO FORMULA IS	TCO CATEGORY	NOW	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
	Contract Quantity	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000
Initial Acquisition Cost	**Acquisition Price**								
	Contract Price Per Unit	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00
	Raw Materials Escalator/De-escalator (%)		0 %	0 %	0 %	0 %	0 %	0 %	0 %
	Labor Escalator/De-escalator (%)		0 %	0 %	0 %	0 %	0 %	0 %	0 %
	Currency Escalator/De-escalator (%)		0 %	0 %	0 %	0 %	0 %	0 %	0 %
	Other Escalator/De-escalator (%)		0 %	0 %	0 %	0 %	0 %	0 %	0 %
	Other Escalator/De-escalator ($)		$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Initial Contract Quantity	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00	$ 45,00
	Additional Upfront Quality Cost								
	Anticipated Defect Rate %	5,0%	4,0%	3,0%	2,0%	1,0%	1,0%	1,0%	1,0%
	Extra Quantity Ordered to Cover Defective Product	527	417	310	205	102	102	102	102
	Less Discounts Taken								
	Payment Terms Discount	1 %	1 %	1 %	1 %	1 %	1 %	1 %	1 %
	Quantity Discount	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
	Rebate / Discounts	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
	Rebate / Discounts ($)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Less Discounts Taken								
	Total Initial Acquisition Cost								
Plus Additional Internal Upfront Costs	**Planning and Specifying:**	NOW	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
	Planning and Specifying Costs	$ 1 200	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total Planning and Specifying								
	Engineering and R&D:	NOW	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
	Prototype & Testing Costs	$ 60	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Other Engineering and R&D Costs	$ 1 000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total Engineering and R&D								
	Qualification & Discovery	NOW	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
	Travel Costs	$ 12 000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Other Qualification & Discovery Costs	$ 12 000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total Qualification & Discovery								
	Industrialization, Tooling & Start Up	NOW	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
	Machinery Acquisition Cost	$ 30 000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Tooling Cost & Amortization	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000
	User Training	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000	$ 5 000
	Set-up Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total Industrialization, Tooling & Start Up								
	Total Upfront								
Plus Ongoing Operating Costs	**Ongoing Operating**	NOW	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
	Contract Management & Supervisory Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Travel Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Energy & Utilities	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Technology and IT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Additional Labor	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Inbound Inspection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Technical Support	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Field Maintenance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Rework	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Field Failures	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Extended Warranty	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Out of warranty claims	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Disposal, waste & scrap	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total Ongoing Operations								
Plus Inventory Costs	**Inventory**	NOW	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7
	Beginning Inventory	0	2 000	3 600	2 720	2 544	627	531	105
	New Quantity Purchased	10 527	10 417	10 310	10 205	10 102	10 102	10 102	10 102
	Defective Goods	(527)	(417)	(310)	(205)	(102)	(102)	(102)	(102)
	Percent of Inventory Sold to Customers or Obsoleted	80 %	70 %	80 %	80 %	95 %	95 %	99 %	99 %
	Inventory Sold to Customers or Obsoleted (Count of Units)	8 000	8 400	10 880	10 176	11 917	10 096	10 426	10 004
	Ending Inventory (Count of Units)	2 000	3 600	2 720	2 544	627	531	105	101
	Average Inventory in Period (Count of Units)	1 922	3 703	4 045	3 500	2 436	1 430	1 169	954
	Average Inventory @ Current Cost	$ 86 490	$ 166 635	$ 182 025	$ 157 500	$ 109 620	$ 64 350	$ 52 605	$ 42 930
	Total Inventory Carrying Cost								

13.3 Appendix C, Questionnaire 1

We herewith ask you for your support by answering briefly the following two questions:

Do you consider at your location Total Cost of Ownership (TCO), i.e. when evaluating issuing POs to suppliers (cost of transaction, quality costs, delivery delays, etc.)

If so, how do you calculate / estimate these costs? If possible, please send a link or attach a copy of the model / system / file you use.

Which cost drivers do you consider the most important in addition to price when evaluating suppliers or calculating total cost?

13.4 Appendix D, Questionnaire 2

Do you think it is necessary to use a TCO model for FMC's suppliers?

2. Would you prefer a TCO model that provides the supplier specific cost in $, or one that gives the supplier specific cost as an index (i.e.1,3*purchase price)?

3. Please rank the following cost drivers that were determined in the answers we received earlier (please mark with 1 - for most important to 7 - for least important):

On-Time Delivery (cost of delivery delays)

Quality cost

Travel costs for supplier visits

Supplier Development costs

Transportation~~s~~ cost

Expediting cost

Inventory related cost

4. How much time would you be willing to use for a TCO analysis (i.e. hours per quarter), and what level of correctness/deviation would you expect and accept (i.e. 100% correct or 80 ± 10% correct

5. Is there a defined and written sourcing/supply chain strategy in your location? If so, please attach a link or document.

6. What is your experience with finding relevant data in SAP that can contribute to estimating the true cost of the above mentioned cost drivers? E.g. time spent for processing poor quality items from a specific supplier that will make up the true cost of quality. Or finding data that can contribute to determine the true cost of a late delivery? Or cost related to expediting goods at specific suppliers?